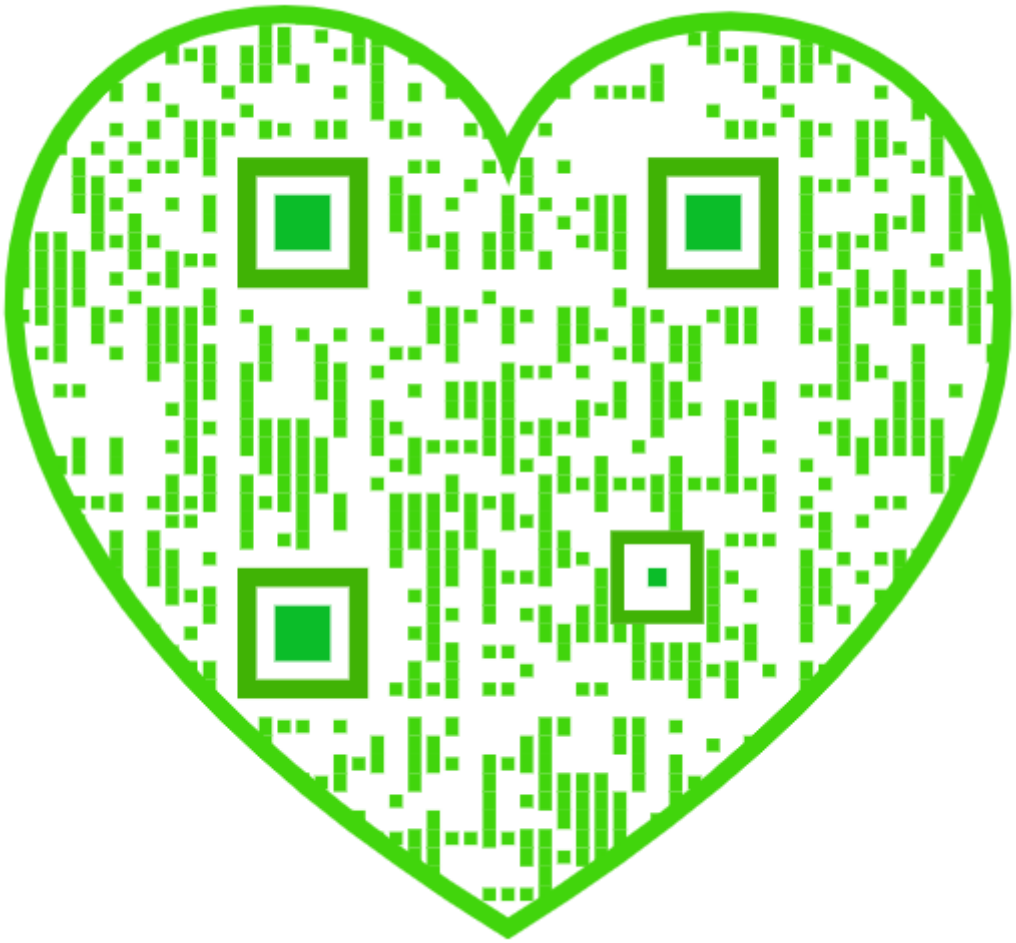

CONSIDERATIONS

UPON

THE ART OF MINING.

TO WHICH ARE ADDED,

REFLECTIONS

ON

ITS ACTUAL STATE IN EUROPE,

AND

THE ADVANTAGES WHICH WOULD RESULT FROM

AN INTRODUCTION OF THIS ART

INTO

THE UNITED STATES.

BY W. H. KEATING, A. M.

"The art of our necessities is great
"That can make vile things precious."
SHAKSPEARE.

Read before the American Philosophical Society, July 20th, 1821.

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ON THE ART OF MINING.

THE importance of a science, or of an art, may probably, in most cases, be considered as proportional to the attention which it has received from mankind in general, or to the degree of perfection which it has attained. This method of testing the importance of an art cannot, however, be said to be correct in all cases. There are, we believe, some very important arts, which have been overlooked by the majority of men, and which have consequently not kept pace with the progress of knowledge. Among these, the ART OF MINING is to be ranked.

The subject to which we propose to call the attention of this Society, in the present communication, is one which has been very incorrectly judged of, even by those upon whose authority we are accustomed to rely in every respect. The art of mining has been, we apprehend, misjudged by the generality of writers; and many individuals have been led into false and disastrous speculations, by engaging in undertakings of this nature, without having sufficiently studied and comprehended the subject. The errors of writers upon this matter have chiefly resulted from their having treated it too slightly, or too exclusively. Thus, many distinguished authors, among whom we may rank the celebrated author of the "Wealth of Nations," have underrated the art of mining, because they had not sufficiently examined its nature and object. They have often mistaken the greedy speculations of the first adventurers in South America, and the visionary plans of the settlers in the country so pompously styled "El Dorado," for the steady, persevering, and arduous labour of the true miner. They have overlooked the advantages which England has derived from her coal and iron mines, and have only noticed the ruinous speculations of ill-advised adventurers: as well might we undervalue the

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advantages of commerce, on account of the failure of the South Sea scheme. Other authors, again, have treated this subject too exclusively. This defect exists chiefly in the works of German authors, who, blinded by their partiality for their profession, would have given it a degree of importance to which it was not entitled. Their wish was to see introduced into large monarchies the same institutions which had been found to answer in the small communities which composed the German empire, and of which a few still subsist, having weathered the political storms of the last thirty years. But a system which answered in a small principality, in which the sovereign acted for the most part like a father of a family, (possessed, it is true, of great powers and privileges, but not regardless of the interests of his subjects,) could not be adopted in larger communities, where the king acts under the influence of his ministers, and where he cannot be directed by those paternal feelings, which, it is but justice to acknowledge, often actuated the lesser princes of Germany. Still less could the plans recommended by these authors be adopted, or even approved of, in this country, where we are so jealous of the rights of property, that nothing but the most imperious necessity could induce us to part with any of those rights.

The art of mining is one of the most important branches of public economy. The nature of this art,—the objects which it embraces,—the studies which it requires,—the benefits which result from it to man, both by administering to his necessities and by increasing his comforts,—and, finally, the great assistance which it offers for the successful prosecution of natural science in general, tend to make it one of the noblest and most interesting pursuits to which the attention of man can be called.

It is, we believe, almost impossible to determine with precision the influence which the art of mining has had in civilizing mankind. The imagination can scarcely conceive the wild and blank state of a nation destitute of all the metals, salts, and fuel, which we derive from mining. There is, we would be induced to believe, but one stage lower than this

in the scale of human ignorance,—and it is that of those Indians who are said to have been unacquainted with the existence of fire.

The art of working the metals must, in the origin, have been the effect of a first advance towards civilization; since which, it must be considered as a cause, as well as an effect, of civilization. Every improvement in this art must necessarily have had a striking effect upon the state of society; which effect was again reflected upon the art from which it sprung. Whatever may have been its influence in producing the present refined state of society, no question can exist as to its importance and advantages at this time. When we consider that the most valuable aliments we take are produced by agriculture, and that agriculture must cease to exist as soon as it is deprived of the assistance of the metals, we can readily conceive how essential this class of substances is to our existence, and how valuable is the art which teaches us to convert the crude and brittle ore into the malleable, pure, and polished metal.

But these are not the only benefits which it affords us. The wool which we manufacture into cloth could never have assumed that form, if it had not previously undergone operations in which metallic instruments are indispensable. The habitations which protect us against the inclemency of the weather, from the cottage of the peasant to the palace of the monarch; in a word, every art which tends to the support or comfort of life,—all evince the indispensable use of metals.

The origin of the art of mining, like that of many others, must have taken place at a very early period, and the date of it is not to be ascertained. The oldest books with which we are acquainted speak of it in very plain terms:—

Thus, in the Genesis,* we find it written:

"And Zillah, she also bare Tubalcain, who was an instructor of every artificer in brass and iron."†

The discrimination of the metals must have taken place

* Chapter IV. verse 22.

† We find a different version of this text in other Bibles, where Tubalcain is said to have been "a *hammerer* and artificer in every work of brass and iron."

as soon as man began to look around him. Accordingly, we find, in the description of the spot where the Garden of Eden stood, speaking of rivers,*—

"That is it which compasseth the whole land of Havilah, where there is gold."

"And the gold of that land is good: there is bdellium and onyx stone."

Again, we find it stated,† that

"Abram was very rich in cattle, in silver, and in gold."

In the writings of Homer and Hesiod, the oldest profane authors whose works have been handed down to us, frequent allusions are made to the metals; and some interesting observations on the state of the art can be extracted from them.

It would be an useful and an interesting task for the antiquary, to endeavour to ascertain the manner in which the ancients smelted their ores and worked their mines. No doubt, their first attempts were rude, and on a small scale; but on such a subject, all additional information, however minute and trifling in appearance, would be interesting. It would throw much light on the progress of civilization; and it would be very desirable that a person well skilled in the dead languages, and well acquainted with the metallurgical processes now in use, would endeavour to trace the progress of the art from its origin, and to determine the respective periods at which each metal was first made known and brought into use.

But it is enough for us to have called the attention of the antiquary to this subject. We cannot enter into details, but hasten to the main object of this communication, which is to draw the attention of the Society to a subject which may become highly interesting to our country.

"Sella quoque genuit Tubalcain qui fuit malleator at faber in cuncta opera "æris et ferri."

If the word *malleator* (hammerer) be not an interpolation of the translator, it presents us this interesting observation, that the ancients had already noticed that property of metals which we call *malleability*, and that they purified their metals by *hammering*.

* Chapter II. verse 11, 12. † Chapter XIII. verse 2.

We shall divide what is to be said on this subject in three parts.

In the First Section we shall state the object of mining, and the various operations which the miner has to perform. We shall make known the sciences upon which his art is founded, and the manner of applying them.

In the Second Section we shall examine the nature of mining, ascertain to what class of property mines belong, and determine the importance of this art compared with others.

The Third Section shall include a short sketch of the actual state of the art in Europe; to which we will add remarks on the advantages which might accrue to the United States from the introduction of this art. We shall inquire into the obstacles which might retard or obstruct the progress of mining in this country; and what course should be followed in order to overcome these obstacles.

SECTION FIRST.

Of the objects of mining, and of the operations which the miner has to perform. Of the sciences upon which his art is founded, and of their application.

The art of mining is that which teaches us the manner of obtaining and preparing for the use of man the metals and other substances which exist in the mineral kingdom.

The metals are seldom found pure:—when pure, they are termed *native*. For the most part they exist intimately mixed, or chemically combined with other metals, and with sulphur, oxigen, and other bodies. In this state they are called *ores*. Iron, the most useful of all metals, has, perhaps, never been found native; lead and tin, certainly never; zinc and cobalt are always extracted from their ores. The native mercury and antimony are so rare as to be merely objects of curiosity; and all the mercury and antimony of commerce, are obtained by extracting these metals from their

combinations with sulphur. Copper is often found native; but always in small quantities. It is from its ores that it is produced in greatest abundance. Silver is often, and gold always, found native; and these, with the addition of platina, are the only metals which exist in sufficient abundance in the native state, to make it an object to work them in that state.

But besides the substances which are chemically combined with the metals to form the ores, there are a number of others which are only mechanically mixed, and which can be easily separated. These are for the most part earthy minerals.

The task of the miner may be said to consist in the following operations:—to find the ore—to extract it from the bosom of the earth—to raise it to the surface—to separate the substances which are mechanically mixed—and then to submit the ore to such metallurgical process as shall purify it and free it from all the substances which remained in chemical or mechanical union with the metal. In a word, to bring the metal to that state of purity which is required for the arts. But, in the performance of these multifarious duties, the miner will meet with obstacles; these he must remove or overcome. Thus he will find himself in the midst of loose and disaggregated materials, which threaten him with instant destruction. To this he must bring a remedy. Again, he will meet with great volumes of water which would soon inundate his works if he could not find means of removing them. In some cases also, the light which he uses to guide his uncertain steps, becomes his most dangerous enemy; it inflames the atmosphere, an explosion takes place, and the miner has ceased to live. To this evil a remedy has been applied by that great and powerful genius, Sir Humphry Davy, whose safety lamp insures him the gratitude of all concerned in these dangerous works. Our task would be endless if we were to attempt to enumerate here every obstacle which the miner has to encounter. We will now proceed to examine the various attainments necessary to the perfect miner:—

1. The knowledge of minerals, or MINERALOGY. This teaches him to distinguish the useful from the unproductive minerals; to ascertain the nature of each substance, and the use to which it may be applied. Without the knowledge of mineralogy, the miner would be led into innumerable mistakes. This is, as it were, the corner stone of his edifice.

2. The knowledge of the distribution of minerals upon the surface of the earth. This science forms a part of GEOLOGY. By it we are enabled to determine with a greater or less degree of certainty, where, and under what circumstances, we may expect to find the minerals we are in search of. It serves to inform us how far we may be justified in searching after certain ores, in certain rocks; and, as an instance, we may mention, that the miner acquainted with the first rudiments of geology, would not search for tin ore in a bed of chalk, any more than he would expect to find rock salt in granite. For want of sufficient regard to this science, great expense has often been unnecessarily incurred by boring or pitting for coal. In many places, expensive works were commenced by uninstructed men, who merely took into consideration the advantage which might be derived from the discovery of this fuel, without reflecting whether they were warranted in so doing by any reasonable expectation of finding it. But we must be very guarded in the application of our geological notions, because they are not founded upon demonstrated facts or impossibilities, but merely upon analogies. It is because tin ore has always been found under circumstances very different from those in which we find chalk, that we are induced to believe, *a priori*, that it will not be found with it. But there is no physical impossibility in its being found in the United States in a different situation from that which it presents in England, Germany, France, and Mexico. We should be directed, not blinded, by analogy; we should consult it as a prudent, but not an infallible adviser.

3. The third branch of the miner's studies is DOCIMASY, or the art of analyzing minerals. To this branch we are indebted for all that we know of the component parts of each mineral. It is upon docimasy, that the great responsibility

(if I may here apply the expression) of the miner's success rests. Without docimasy, mineralogy would be a science of but little use. The mineralogist, it is true, might probably distinguish his minerals without, as well as with, its assistance; he might give them names, and call them *a*, *b*, or *c*, but it is the docimastic chemist, who, having analyzed them, determines their nature, and affixes their value; it is he who stamps upon them the rate at which they are to be received in commerce; it is he who tells us that what the mineralogist had called *a*, was an ore of iron, which might be worked with advantage to procure this metal; that the *b* of the mineralogist was an useful stone, from which lime might be obtained for the arts; while his *c* had no intrinsic value; that it might indeed adorn his cabinet, or be made to sparkle in the hands of the able jeweller, but that it never could be of any use in the arts. Thus the docimastic chemist may be said to give value to the science of the mineralogist. But he goes further; after he has determined that a given mineral is an ore of a certain metal, he tells us with what substances it is combined, in what proportion the metal exists, whether the combination be an intimate mechanical mixture, or a real chemical combination, in definite proportions. And this is not all; he tells us if the ore can be worked with advantage, and in what manner; whether any, and if any, what substances are to be added or taken away in order to reduce it to that state of purity which is requisite in the arts. Thus we see how necessary to the miner is an acquaintance with docimasy, and how often, and how severely that man may be disappointed, who looks for success without a previous acquaintance with this science.

4. The fourth branch which enters into the studies of the miner is the knowledge of those indications by which we may determine the extent and importance of a mineral deposit, the existence of which has been previously ascertained. This is indeed a very important branch of his art; it is one upon which much depends in a new country; we will, therefore, not hesitate to speak of it in detail. It is a common idea, that a person acquainted with mining, can, from a mere in-

spection of the surface, decide whether there are any mines under ground. This opinion is, however, incorrect; the richest ores may be covered by a layer of vegetable earth, which conceals them entirely from the observation of the miner. The characters taken from the general appearance of the ground, as respects roughness or evenness, have long been supposed to be useful in the hands of the skilful miner; but we would observe, that the loftiest and most rugged peaks of the Alps present no mines whatever, while the level and fertile plains of Poland and Belgium cover rich deposits of coal, iron, lead, zinc, salt, &c. It was at one time imagined, that the presence of metallic deposits produced a sort of internal fermentation, which impeded the progress of vegetation, and stinted the growth of trees; to this we answer, that the German empire, than which none is richer in mines, was at one time a complete forest, and covered with the finest trees. To the beauty and richness of these forests, the Roman authors have borne testimony; and it stands upon record, that the whole of the present rich mining district of Freyberg in Saxony, was at one time one of the thickest and wildest forests in the empire, and that its trees had attained an uncommon size. It is true, the land is now bare, and scarcely does an "occasional pine" shade the cottage of the poor miner; but this we must attribute to the works of man, and not to the action of the veins placed there by nature. How could it be otherwise, in places where we see that the ground has been broken up in every direction, where heaps of rubbish have been formed, and subsequently scattered upon the country, and where the very streams which supported the vegetation, have been diverted from their natural course, and made to run into new channels?

Another indication, which has been used, we believe, not with the purest of motives, was that of the *divining rod.*— Men were led to believe, that with the assistance of a rod, generally of hazle, or some such wood, the presence of mines, of salt, of springs, in a word, of every thing that was wished for, could be discovered. Secret treasures, it was reported, owed their discovery to this means. To those who reflect

how great an influence the astrologers have possessed over mankind, and how apt the imagination is to be carried away by a sort of admiration for every thing which bears the appearance of being supernatural, it will be no cause of wonder, that in the dark ages of superstition and ignorance, the belief in the divining rod, like that in witchcraft, dreams, fortunetelling, &c. should have existed not only in the multitude, but even in many men superior to the time in which they lived. Indeed, such deceptions are so fascinating, that there are perhaps few persons who have read the brilliant descriptions of the power of the magic wand in the oriental tales, and have not felt a secret disappointment at the recollection that it was but an airy vision, and a wish that it might be embodied into reality. This disposition for the marvellous being incontestable, it is not surprising that cunning impostors should have existed, who found it their interest to increase this belief, and to keep up the hopes of their votaries by pretended discoveries and wonders, the explanation of which could not have been readily given to, or understood by, the unenlightened multitude before whom these were performed. But as men became more enlightened, and as they felt the necessity of discrediting every thing which could not be proved, the confidence in the powers of the divining rod declined, and there are but few, we believe, who place any reliance in it at present. We would not even have dwelt so long upon this subject, if we had not seen, in a late very respectable publication,* the divining rod mentioned as an agent, whose efficacy was still the matter of doubt.

We repeat it, the miner has but few indications to direct him in the search of ores; it is chance which throws them in his way; the richest mines known have been discovered by the merest accident. The labourers in the fields are those who have the best opportunity of discovering the first *indicia* of a mine; the plough accidentally turns up a stone which the ploughman picks up; its weight surprises him; it sparkles in the sun; it has the characters of a metal; he takes it

* Silliman's Journal of Science, No. 7. (Vol. 3, No. 1.)

home with him, and shows it to his neighbour; the fame of his discovery is soon spread about, and magnifies as it proceeds; some traveller acquainted with the subject visits the spot, and ascertains the nature of the mineral found; all this is the mere effect of accident, but here begins the work of the miner; here he may display his ingenuity, or apply the experience which he has acquired; he is told that the specimen which he holds was found in the adjoining field; he examines the field; he compares the specimen; he studies the country; visits the valleys; observes the pebbles rolled by the neighbouring streams, and endeavours by a careful search to trace back to its original situation the specimen which had been accidentally detached from it. Should his researches prove successful, should he have found the vein or bed, he examines its nature, ascertains its extent, begins his works, sinks his shafts, and endeavours to determine, by pitting and boring, the importance and value of the mineral deposit. It is at this moment that the true character of the miner may be tested; he must neither fall into despondency at the first failure, nor be allured into hasty and hazardous undertakings at the first appearance of success; he must not be cast down because the path which he was following has suddenly disappeared, but he must endeavour to fall in again with it, by prudently directing his steps in the neighbourhood; if the thread which guided him in the labyrinth has been suddenly cut off, he must not despair, but lighting the torch of science, he must endeavour to recover it, and having obtained possession of it, he may be enabled to renew his search after the concealed treasure. If the miner who is too easily discouraged loses the chance of succeeding, and allows fortune to escape him, he who falls into the other extreme is still more to be blamed; he not only brings ruin upon himself, his family and his friends, but he destroys the reliance which might be placed in his character and abilities; he injures the profession of which he is a member, by taking away from it the small degree of certainty which it possesses, and making it appear as a tool in the hands of an impostor. The prudent and skilful miner will therefore endeavour to

steer a middle course, free from the dangers which threaten him on both sides; he loses no time, overlooks no indication which may assist him, considers, examines, studies every appearance, reflects maturely, and then decides whether the deposit be worthy of his attention or not; he may be mistaken in his decision, but he has acted prudently and wisely, and whatever result attends his future undertakings, he always feels proud at the consciousness that he has done all that he could do, and that in his profession, as well as in every other, a man may deserve and not obtain success.

5. The fifth branch which the miner has to study, is the manner of working the mine; properly speaking, "*Hoc opus, hic labor est.*" This consists in the knowledge of all the various operations which are performed under ground; these operations cannot be well described on paper; it is impossible for a person who has not visited a mine to form a correct idea of its nature, or to imagine the subterraneous world which exists there; without having witnessed them, it is not easy to conceive the nicety which is required in some of the miner's works, the certainty with which he directs himself by the mere assistance of his compass; the accuracy with which he executes, under ground, the operations which he has designed on his draughts and map.

The works which the miner has to execute are the sinking of pits and shafts; the opening of galleries, levels, and drifts; the excavating of large chambers for the reception of machines, &c. the detaching of the ore from the rock, &c.

All these works he executes either by the assistance of iron and steel tools, such as pickaxes, hammers, wedges, &c. or by blasting the rock with gunpowder, in which case, he uses the drill, rammer, priming rod, &c. or finally by the application of fire; this last method, which is practised with advantage in many instances in Germany, Sweden, and Russia, and which can be applied with great success wherever the rock is tough, wood cheap, and powder expensive, is very interesting. It consists in erecting large piles of wood near the rock intended to be taken down, setting the wood on fire, and directing the flame and smoke in the manner that will

produce the greatest effect upon the rock, which is expanded and rent in all directions, by numberless fissures; new fuel is added, and the fire kept up for several days, at the end of which the miner returns to the spot of the conflagration, and easily detaches, with his pickaxe, the rock, which, before the application of the fire, was very tough and compact, but which afterwards almost crumbles into dust of itself.

To this and the preceding branch we must refer the knowledge, so essential to the miner, of following the traces or indications of a vein which has partially or completely disappeared. This branch includes likewise the whole disposition of the works under ground. It therefore requires, on the part of the miner, experience and study, to know how to direct and dispose the works, in order to extract the ore with the greatest economy. It is a branch in which rules can scarcely be laid down. Every mine requires a peculiar disposition, and it is only by comparing his mine with those which exist in other places, that the miner can arrive at a good and satisfactory disposition of his works. To this branch we must likewise refer the knowledge of the best methods used to judge of the strength and quality of powder, of the resistance which it can overcome, and of the quantity necessary to attain a certain object; also, of the proper manner of applying it in mines.

6. We have said, that in the accomplishment of his work the miner met with great obstacles, which it was necessary for him to remove. The first of these is that arising from the pressure of the roof and sides of the excavations which he has made. The knowledge of the methods used to overcome this difficulty, constitutes the sixth branch of the art of mining. It is an observation of every day, that if an excavation be made in the soil, and left to itself, it will, after some time, become partly closed up by the lateral pressure; and if it were intended to make the excavation in sand or gravel, it would require great care to prevent the sand from falling into the hole as soon as made. Every body, however unacquainted with the art of mining, knows that when a well is dug, unless it be opened in the solid rock, it is indispensa-

ble to build up a solid wall of stone or brick round the well. It is true, many imagine this to be built for no other purpose than to keep in the water, but the main object is to prevent the sides of the well from falling in. If this be the case when a well of thirty or forty, or at most one hundred feet, is dug, how much more important when the shaft extends to a depth of from fifteen to sixteen hundred feet,* when the dimensions of the shaft are much larger, and when it traverses many different beds, some of tough and hard rocks, others less solid and compact, some of loose and disaggregated materials, some of clay, sand, &c. the whole very much impregnated with water—it is evident that in such a case the difficulties must increase in a tenfold ratio. Besides these, the miner has often to open large subterraneous chambers, the roof and sides of which are far from being solid; these chambers, however, require to be constructed with a great degree of solidity, as they are intended for the reception of large and expensive machines, such as steam-engines and water-wheels, in which case, the constant agitation of the air, by the motion and fall of water, tends to destroy the equilibrium of the rock, at the same time that the spray and moisture necessarily proceeding from such machines, act as a corrosive upon the rock. These chambers are sometimes intended for the accommodation of horses, sometimes for mills for the pounding of ores, &c.: hence it is evident, that the greatest care should be bestowed upon their solidity. The miner has two ways of propping the sides of his excavations. The first is by carpentry, the second by masonry. The proper application of these two methods is not unattended with difficulties. It is, generally speaking, much cheaper to use timber than stone; but the works of stone, if well made, may be considered as everlasting in mines, while those of wood re-

* The shaft called the *Richtschact*, at the mine of *Beschert Glück*, near Freyberg, in Saxony, extended, in 1820, to a depth of 1981 feet, on a vein, the inclination of which is about forty-eight degrees. The shaft is in its upper part perpendicular: after a certain depth, it follows the inclination of the vein. This vein has been very productive in silver ore, and is known by the name of *Neu hohe Birkner Stehende Gang*.

quire frequent repair, and a total renewal after a few years. It is not enough, therefore, to consider the comparative prices of each; but we must also take into consideration their respective durability, and the time which it is intended that the works shall last; for, in mines, some works are intended to be permanent, while others are merely temporary; some are expected to remain open as long as the mine shall be worked, while others are only worked for the ore which they contain, and are abandoned as soon as that ore is exhausted. In the latter works, no doubt can exist as to the advantage in using timber in preference to stone; for not only it is much cheaper, but in many cases a great portion of the timber used can be removed to another place, and the materials are not therefore lost. But in the permanent works, the question is more difficult to decide. In Germany, where timber is becoming scarcer every day, masonry has been substituted with advantage in many mines where timber was formerly exclusively used. In this country, it is probable that timber will, for a long time to come, offer a great economy over stone works. Next to the choice of materials, the miner must attend to the study of the form and disposition of the carpenter or mason's work. These, of course, depend upon the form and nature of the excavation, upon the object for which it has been made, upon the solidity of the rock, the quantity of water, &c. We shall not enter into particulars, which would unnecessarily lengthen this communication, but merely observe, that this branch of the miner's art includes a knowledge of the strength and resistance of timber, of the solidity of building materials, of the manner of making cements, of the construction of arches, of the forms best adapted to each particular case, and of the calculations of the forces necessary to break them, &c.

7. It is a well-known fact, proved by daily experience, that if a well be dug, it will, at a certain depth, which varies according to the nature of the rock, and to the locality, become partly filled with water. Nay, it has been observed, that in some places, the water will spout out in the form of a *jet d'eau*. This circumstance, so useful in common life, since

it allows man to fix his habitation far from running water, is the source of much trouble and of great difficulties to the miner; for as soon as his excavations have attained a certain depth, the water runs in from all sides, inundates his works, and would compel him to abandon them, if his ingenuity could not devise means of keeping them dry. The study of the means used to accomplish this end, constitutes the seventh division of his acquirements. The object which he has in view is twofold;—either to prevent the water from entering into his excavations, or to drain it off when it has penetrated into them. If the first method were practicable in all cases, it would undoubtedly be far preferable; but this, unfortunately, is but seldom in his power; the means used to prevent the water from entering the excavations being the damming up of the side from which it comes, and opposing a strong barrier in that quarter. This method is, however, impossible when the waters come from all directions, as is frequently the case, or where they proceed from the direction which the miner intends to follow, as usually happens in mines worked upon veins. Under these circumstances, the miner must think of removing them. He has two ways of attaining this end. The first is to give the waters an outlet, by opening a drift, communicating with the surface at some distance. The water is made to take its course along this drift. When this resource fails, from the nature of the country, the depth of the mine, or some other reason, the only means left is to have recourse to pumping engines. The pumps are set in motion by animal, water, or steam power. The animal power is in some cases that of man; more usually it consists of horses. As the pumping of the water is always attended with a vast deal of expense, this operation is avoided as often as possible. A drift, or drain, is therefore opened whenever the local circumstances admit of it. Some drifts are made at great depths, and extend to great distances.* It is generally con-

* The length of the drift in the district of Freyberg, including all the branches connecting it with every mine, measured, in 1819, 70,000 German *Lachters*, or upwards of 90 English miles. What an immense undertaking! and how great must be the advantages of drifts, in order to compensate for such subterraneous aqueducts!

sidered, that the money laid out in drifts is very soon repaid by the economy of the pumps. Drifts, moreover, offer this advantage, that they allow the miner to carry his works to a much greater depth.

This branch of the miner's studies comprehends, therefore, the art of making dams; that of excavating the rock, as in the third subdivision of this section; the knowledge of mechanics, hydraulics, and hydrostatics; the science of machines, and of their proper disposition and application.

8. Another and a very important branch of the miner's studies, is that of ventilating the mine, so as to procure a constant supply of pure air. This object is particularly entitled to the attention of the miner, since not only the security of the mine, and the durability of the materials, depend upon it, but even the preservation of the lives which are intrusted to his care, and for which he must consider himself responsible, should any accident happen through his carelessness or neglect. The air in the interior of mines is generally pure, but it requires a constant renewal; for the oxigen which it contains is continually absorbed by respiration and combustion, and converted into carbonic acid gas. The inflammation of gunpowder likewise tends to diminish the quantity of oxigen in the air, by giving rise to new compounds, which do not support life and combustion. If, therefore, a regular and perpetual current of air were not kept up, the atmosphere of the mines would become so foul as to cease to support combustion, the lights would be extinguished, and, after a certain time, its action upon animal life would be fatal. In some cases, a new cause operates, in like manner, to corrupt the atmosphere. This is the foul air produced by the rock itself. It occurs principally in coal mines, where the coal constantly emits a quantity of gases, which not only cannot support animal life, but even in many instances are susceptible of being inflamed, and give rise to explosions which have often proved fatal to many of the workmen employed in the mines. Some coal mines, particularly in England, produce so much of this inflammable gas, that it had been found impossible to keep lights in them, until the late discovery of the safety lamp, to

which we have already alluded, and which has hitherto answered in every case in which it was properly applied. In the invention of this lamp, Sir Humphry Davy has shown the great benefits which may result from applying theoretical knowledge to practical use. Having found, by a series of interesting experiments, that the flame of a candle could not pass through a metallic gauze of a certain fineness of texture, he conceived the idea of enclosing the miner's lamp in a cylinder of iron wire gauze, so secured as to prevent any communication of the flame with the air of the atmosphere, except through the holes in the gauze. The experiment has been crowned with the most complete success; and this invention is undoubtedly one of the most valuable to humanity.

The miner has several ways of ventilating his mines, all of which are attended with more or less expense. To enable him to apply these methods with judgment, propriety, and economy, is therefore the object of the eighth branch of his studies. It includes, likewise, the knowledge of the best means of lighting the mines, and of the various kinds of lamps and torches which have been used.

9. The ninth division of the miner's acquirements is the carriage of the ores in the mine from the spot whence they are extracted to the bottom of the shaft, and then the raising of the same from the bottom to the mouth of the pit.

The first part of this task requires some acquaintance with the nature of a mine, and some experience on this subject; for the carriages under ground are attended with greater difficulties, and a much greater expense, than those at the surface. There are various methods; one of the least known, and which is very seldom used, probably not so often as it might be with advantage, is that of internal canals, the drifts being used for that purpose, and the ore being conveyed in small boats. A very pretty application of this method exists in the neighbourhood of Alston Moor, in England, where boats of upwards of five feet in breadth are navigated upon this subterraneous canal.

As to the raising of the ores to the mouth of the pit, it is done by means of machines, for the most part similar to, and

often connected with, those used for pumping out the water. To the division which treats of the pumping of waters, this part may therefore be referred.

10. The tenth branch, which the miner ought to study, is that of dressing the ore. By dressing the ore, we understand the operations practised to cleanse it of all the heterogeneous particles with which it is mechanically mixed. These operations consist in picking, pounding, washing, &c. This matter has been neglected in England to an astonishing degree. In France, it is better understood; but it is chiefly in Germany that it is to be studied. Nowhere has the art of dressing the ores been brought so near to perfection. It is almost impossible to conceive, without having seen it, how far the Germans excel all other nations in this important subject. The first improvements in this art are due to the Hungarians, whose ingenuity was brought into play by the desire of extracting the gold which exists in a very trifling quantity in the sands of their rivers, and also disseminated in the earthy gangue of their veins. The first improvements made by the Hungarians were subsequently introduced into Saxony and the Hartz, where the poorest silver and tin ores are worked, with a degree of economy almost incredible. The operations in dressing the ores have for their object to separate the substances which are mechanically mixed with them, and which are commonly called *gangue*, or often very improperly, *matrix*. In the washing of the ores, many different plans have been pursued; but of these, none is so advantageous as that of the *shaking* or *percussion tables*, which are set in motion by water-wheels, and, from their peculiar construction, economize about four-fifths of the hands formerly employed for the purpose of washing the ores.

11. We have seen, that among the operations of the art of mining, many required the use of machines which it is often desirable to set in motion by a water power. This power is not always at hand: it must be procured from a distance, which is accomplished by means of canals and aqueducts. In some of the more considerable mining districts of Europe, these aqueducts are made of a great length, and often extend

to twenty miles, and even more. To be enabled to construct these aqueducts, it is necessary to be acquainted with civil engineering, and it certainly would be very desirable that any man who has any pretensions to be reckoned a perfect miner, should not be a stranger to these operations. Numberless cases will occur, in the working of a mine, in which the operations of the mining engineer differ but little from those of the civil engineer.

12. But a much more important branch of the miner's pursuits, one to which all the others are directed, and by which the ore is most effectually improved, is that of METALLURGY.

Metallurgy, or as it has been more properly termed of late, MINERALURGY, is that portion of the miner's studies which enables him by the action of heat, assisted by other agents, for the most part chemical, to counteract the affinities which unite the various components existing in the crude products of the mines, and to separate from them the substance which was the object of mining, in order to reduce it to such a state of purity as will render it fit for the various purposes for which it was intended; it not only separates the bodies chemically combined, but also those which are mechanically united in quantities too minute, or by a mixture too intimate to admit of a separation by picking and washing, &c. It is, therefore, by the assistance of metallurgy that we are enabled to separate and extract silver, lead, and copper, from some combinations in which they are mixed with iron, antimony, arsenic, zinc, sulphur, lime, magnesia, and other substances, whose names are only known to those who have made a study of chemistry.

Metallurgical operations are the last which the miner has to perform. They are, at the same time, the most complicated, and the most difficult. It is not enough for the metallurgist to separate the greater part of the metal, but he must separate the whole, if possible; and what is more, he must do it with great economy. He must not be satisfied with the results which he has obtained; he must constantly endeavour to improve his process. Metallurgy is a science in which much remains to be done. It is, therefore, incumbent upon

the metallurgist to be ever watchful, and to endeavour to attain a greater degree of economy and precision. This he may be able to effect by studying well all the operations practised at this time, and those which have been formerly practised, but have since been abandoned. He must endeavour to ascertain why they have been given up. He must inquire into the rationale of all his operations; examine and analyze all the products obtained. By these, and similar means, he may hope for success.

Among the most important branches of the metallurgist's studies, is, undoubtedly, that of the construction of his furnaces. It is one on which too much care cannot be bestowed. He must, likewise, become well acquainted with the nature and quality of the various kinds of fuel used, the process of converting wood and coal into charcoal and coak, &c.

The principal operations used by the metallurgist to attain his end, are the roasting, smelting, amalgamating, cupelling, and refining, of the ores. If mineralogy be the cornerstone of the miner's studies, metallurgy may with justice be said to be its keystone. It is metallurgy which completes, which perfects the work.

We might easily have lengthened this review of the studies of the miner, by adding a number of branches, and making several subdivisions, which we have avoided in order to reduce it to as small a compass as possible. Nor have we included in the studies of the miner, that of mining jurisprudence, although it is considered in Germany as an indispensable part of his studies. Every officer of mines employed in the kingdom of Saxony, is compelled to attend two years the lectures of the Law Academy at Leipsick, and it is not until he has undergone examinations upon jurisprudence, that he is received as officer of mines. We would not hastily or rashly censure regulations which have been found to answer during centuries, and which come down to us sanctioned by experience and time; but we would observe, that although this study may be very necessary in Germany, where the laws and regulations on mining are numerous and

complicated, it does not appear to us that this study is more necessary to the American miner, than to the possessor of any kind of property whatsoever, or to the man following any other profession. A general acquaintance with the laws of his country is what every man ought to have; more than this we do not believe to be necessary to the miner.

We now proceed to examine upon what sciences the art of the miner is founded, and how he is to apply them.

From what has been stated in the preceding pages, we think it apparent that the art of mining is founded upon four sciences; viz.

Mineralogy,
Natural Philosophy,
Mathematics, and
Chemistry.

Mineralogy is indispensable to the miner in order to recognise the minerals when he sees them.

Natural Philosophy is necessary, as it comprises statics, mechanics, hydraulics, hydrostatics, and magnetism, which, as we have seen, are useful to the miner in draining the mines of the water they contain—in raising the ores to the surface—in resisting the lateral pressure of the rock—in ventilating the mine—in directing his course under ground by means of the compass—in dressing the ores—in making aqueducts—in constructing blasting machines for his furnaces, &c.

Mathematics are indispensable to calculate the force of his machines, and of his moving powers; to enable him to make correct surveys of his subterraneous works; to assist him in judging of the strength of his constructions both above and under ground.

Upon correct notions of mathematics and natural philosophy depends the successful application of his machinery, whether it consist of horse-engines, or steam-engines, of water-wheels, or pressing machines, &c. If ignorant of surveying, or of the laws which govern his compass, he never will be able to make the different parts of his works correspond with

each other. In vain will he waste treasures in endeavours to open drifts. He will always be foiled in his attempts, because he was deficient in the first requisites.

Chemistry is as necessary to the miner as any other science. Upon an intimate acquaintance with it, his success in a great measure depends. He must have made a close study of this science, both as respects the nicer operations of analytical chemistry, and the great principles of chemical statics, in order to be able to explain and account for the mutual and relative actions of the various substances which he wishes to treat in his furnaces, and to remedy all the accidents which may occur. Docimasy and metallurgy, two of the most interesting and important branches of the miner's studies, depend exclusively upon chemistry. He must, therefore, be master of this science, if he expects to succeed.

If it be remarked, that the studies which we have presented as indispensable for the miner, are so various and so extensive, so general and so difficult, as to render it impossible for a single man to make himself thoroughly acquainted with them all, we answer, that we have intended to show what acquirements a man ought to possess before he could call himself a perfect miner. We are ready to acknowledge that it is impossible for any one man to be equally well skilled in all these branches. It is usual in all the great mining districts of Europe, to divide the task between several men. The isolated mines are confided, it is true, to the care of a single director, who, being unable to attend equally well to the whole, directs his attention more exclusively to those studies which he thinks are most needed in the establishment at the head of which he finds himself placed. But although we admit that a man may neglect or lay aside those branches of the miner's pursuits which he finds less important, (as for instance, metallurgy, if he be at the head of coal mines,) still, we think that he ought always to keep up a general acquaintance with the sciences upon which they are founded, in order that he may have recourse to them whenever he finds it necessary.

But it is not enough to have learnt these sciences in the study or in the laboratory; he must not think that mere theoretical knowledge will avail him much. He must, on the contrary, endeavour to acquire practical information. He must visit the interior of the mines—study the disposition of rocks—examine the manner in which the works are executed—nay, he must himself become an operator—he must have handled the tools himself, or he never can expect to be a perfect miner, or a good judge of the work executed by those under him.

There is no art, perhaps, where it is more necessary, and yet more difficult, to unite practice with theory, than in the art of mining. The man who is a mere theorist, can never form a correct opinion of what a mine is, or how it ought to be worked; he will never know what remedy to apply in case of a failure. Trusting to his drawings or to his calculations, every step which he takes may be in direct opposition to the acknowledged laws of nature. He assumes as principles, rules which have never existed but in his own imagination, and upon these establishes arguments, and draws conclusions, as false as the premises upon which they are founded.

In the course of our very limited experience, it has been in our power to notice several instances of men, who, possessing very deep mathematical information, could have calculated the exact resistance of a beam of wood, and the force necessary to break it; but if brought into a mine and requested to give an advice as to the size of a piece of timber, which could resist the lateral pressure, in a particular case then under notice, found themselves completely at a loss for an answer, and acknowledged that all their theoretic knowledge could not assist them in solving a question, which a mere practical workman in the mine, could, from analogy and by experience, answer without hesitation.

At the same time, however, that we admit that theory alone will not avail a miner much, we should be sorry to see its advantages overlooked; the mere practical miner is apt to be puzzled at the least difficulty; he but seldom improves, generally retrogrades, or follows a blind *routine*.

In order to avoid both evils, we believe it necessary to be acquainted with both theory and practice; to trust in theory as often as its results are not in direct opposition with those of experience; to take advantage of the reasonings *a priori*, in every instance in which the arguments *a posteriori* have not given a decided and incontrovertible answer; in a word, to rely upon theory without being a slave to it.

SECTION SECOND.

Of the nature of Mining. Of the class of property to which Mines belong, and of the importance of the art of Mining compared with all others.

A question which has often been debated among the authors who have written on mining, is, whether it ought to be considered as an art or a science; but this is a mere scholastic puzzle, which has been applied equally to all branches of human knowledge; the miner's profession has its theory as well as its practice; the former entitles it to be ranked with the sciences, while the latter constitutes it an art; it therefore partakes of both; it requires an acquaintance with several sciences and several arts; hence, it is, with propriety, neither exclusively a science nor an art; but it is a sort of middle ground, upon which both may be said to meet.

Another question, and one of much greater importance to the miner, is to ascertain in what class of property mines should be ranked, and if they are to be considered in every respect as real property; there are probably some points of difference between mines and other kinds of property; but the examination of this question appertains more properly to the lawyer than to the miner; we will therefore not enter into a discussion which is beyond our reach, but we wished to call the attention of the lawyer to this subject, which, we believe, has not been very closely examined.

Whatever may have been the motives which induced legislators to separate this class of property from all others, certain it is, that in most countries, the mines have been made the subject of peculiar legislation; we believe that it is principally to their importance to society in general, that we must attribute this distinction; as the metals, the salts, and fuel which are extracted from mines, are admitted by all to be indispensable for the comfort, we might say, for the existence of man, and as they are not to be found indifferently upon the whole surface of a country, but are restricted to particular spots and particular localities, it was thought necessary for the general interest of society, to take away from the owners of these spots, the right of property to those sources of wealth; for, if this right of property were vested in the owner of the land, it would be optional with him to work his mines, or to neglect them; it would therefore be in his power to give to, or withhold from society the comforts and means of subsistence, which depend upon the products of mines; these products being considered as a source of national wealth, were supposed to be national property, which ought to be disposed of in the manner best calculated to secure the interests of the nation at large; it was argued in defence of this doctrine, that a river is not the property of the man upon whose estate it passes; that he enjoys, it is true, all the advantages, and is liable to all the inconvenience, which result from its neighbourhood, without being the proprietor of its waters; that he can only take advantage of them, as long as the use he makes of them does not interfere with the general interests of society. When the injustice of taking away from an individual his property, was urged as a motive against this mode of reasoning, it was answered, that the depriving an individual of a property, upon which he had not depended, could not be considered as an injustice done to him; that he knew not of the existence of a mine under ground when he purchased the spot, and therefore, that his schemes of profit were not founded upon it; that, when a law was passed to take away from the owner of

the soil, the right of property to the undiscovered mines which lay concealed in the bowels of the earth, he could at most be said to be deceived in the hopes which he might have entertained; that this measure, however, affected only the original proprietor, for every subsequent purchaser would be aware of the conditional tenure by which he held the land; and that, although the case of the first owner was hard, it could only be considered as one of the many in which individual interests must be postponed to the general welfare. Another powerful motive for separating mines from other kind of property, and taking them away from the owners of the soil, was the great difference which exists between mines and lands devoted to agriculture, and which consists in this, that the former can be exhausted, or rendered useless to society by mismanagement in the origin,* while the latter possess a perpetual power of reproduction; that, if the powers of the soil be exhausted by some cause or other, they can be restored and reproduced in a lapse of time never very considerable; this is an argument, which, if fairly examined and duly weighed, will go very far; for if mines be productive of great advantage to the community, it is essential for the general benefit of this community that they be worked, and their products brought into circulation; but *further*, it is also necessary that they be worked with the greatest advantage and skill, in order that society at large may derive the greatest possible advantage, from a treasure placed by Provi-

* We have said that a mine can be destroyed, or rendered useless, by mismanagement in the origin. We might cite many instances; a single one will suffice. If a coal mine be improperly worked in the origin, large masses left unexplored, a free access of atmospheric air allowed to this coal, it will be very apt to inflame spontaneously, by the decomposition of the iron pyrites, which accompanies it in most cases; the mine once on fire, there is no saying where or when the conflagration will stop; some of these subterraneous fires have been lasting two or three centuries; not only the coal is lost to mankind, but the surface of the soil has considerably suffered from the smoke and gases issuing, which have produced pressures in the soil, &c. and have destroyed the vegetation over extensive tracts. The great chasms formed under ground by the combustion of the coal, have caused the sinking in of the surface, and many other accidents.

dence upon the property of an individual, for the benefit of the community at large.

Hence the great principle, upon which all the writers upon the law of mining seem to have agreed, that when a mine belongs to an individual, it is a property which he may use, but not abuse; while all other properties which he possesses he holds in most cases with the privilege of using and abusing at pleasure.

It has been further urged, in favour of taking away from an individual the right of property to the mines under his ground, that the division of property is always made with reference to the convenience of the owners of the soil, and that the mines which exist under its surface have little or no connexion with the surface itself, so that a division of property, made to suit the surface, may be such as to preclude the possibility of a mine under ground being worked by the owners of the soil separately; whereas, if the privilege of the mines did not follow the property of the surface, but were vested in a single individual, this individual might work them with profit to himself and advantage to the community. It is from such motives as these, that the advocates of restrictive laws upon mines endeavour to establish the expediency and justice of the right of *Royalty*. This regal right varies in every country. In some, the sovereign is merely entitled to a certain proportion in the profits, or to a share in the products. In other countries, the sovereign, besides his share in the products, has the exclusive right of disposing of the mines, and of conferring them upon those whom he thinks best calculated to secure the interests of the state. In some parts of Germany, the sovereign has moreover the sole right of directing the manner in which the mines belonging to individuals shall be worked. Hence the creation of a regular body of officers, instructed in the art of mining, and to whom is assigned the care of superintending and directing all the mines of the country, whether they belong to the sovereign or to individuals. The creation of such a body of officers was followed by that of public schools and academies, where the art of mining is taught in all its various branches. To

these institutions, no doubt, the art is much indebted for many of the improvements which have been introduced during the last century. But such a system is liable to great objections. It seems to us, that the establishment of officers for the special purpose of directing an individual how he is to employ his property, what expenses he must make, and what profits he may be allowed to derive from them, is an encroachment upon private rights, to which nothing but the most manifest expediency could induce us to accede; and we believe this expediency has not been clearly demonstrated. We admit that there are many instances, in which the interests of society at large, the security of the mines, and that of the lives of the men employed in them, would seem to justify, and even to require, an interference on the part of the legislators. Whenever such an interference can be proved to be necessary, we shall always be disposed to advocate it, even though it affect individual rights; for in societies, it is evident that the convenience of the few must yield to the interests of the many. It is a rule so well established, that we shall not dwell a moment in bringing forward examples, and merely state, that whenever a road or canal is found beneficial to the country at large, no individual can object to its passing over his property, although it may occasion him serious inconvenience. There are numberless other instances which tend to prove, that the great basis of social life being that of mutual sacrifices for the public weal, society at large is perfectly justifiable in compelling an individual to abandon rights which are injurious to it.

Our object, at present, is not to decide what course should be followed in the United States, and what laws ought to be made regulating the rights of miners; and we even abstain from expressing any decided opinion as to the expediency of making any law whatsoever on the subject, our only purpose being to endeavour to call the attention of some able writer to this subject. We would wish that that writer could be found in that class of professional men, who, from the nature of their avocations, have made a particular study of jurisprudence and of the rights of property, and who, from their

general character, would, we are certain, take an enlightened view of the subject, and lend their influence to support any measure, the object of which would be to open a new source of national wealth, and to make our country independent of all others as respects the products of mines, even though such a measure might in some respects curtail the rights of the owners of the soil. We will merely state a few of the many instances which have been brought forward on this question, in order to show how, in some cases, legislative authority might be exercised with advantage. We merely assume, beforehand, what we believe to be correct, that there is no law of the United States, and none of the state of Pennsylvania,* which can be said to apply particularly to mines.

It has often been thought, that the privilege granted to sovereigns had been in many cases most shamefully abused, as, for instance, in England, where the right of royalty over immense territories was lavished by the crown upon individuals who had no claim to it except through the favour of the monarch. It was to reward a chieftain who had been useful to him in wars, that the king would confer upon him the royalty of all the mines found in one or more counties, to the great and manifest injury of the industrious and useful part of the community. This right was afterwards sold and divided by these military lords and their descendants, so that they have now fallen into the hands of individuals who own them often without having any right to the soil under which they may be found. This privilege, originally assumed by the sovereign for the interest of the community, has therefore in this case proved of no use whatever to the state; it has never benefited either the public or the king; but it has

* The reservation of one-fifth of the gold and silver ores for the use of the state, cannot be considered as a law on mining, but merely as a restriction in the sale of the property. We may be allowed to observe, that this reservation is very immoderate; and must either prevent these ores from being worked, or give rise to great abuse. We believe that so great a reservation has been but seldom required, and we know of no instance where a greater one has been called for. The word *ore* is very loose, and will, we fear, give rise to great difficulties, if this law should ever come into operation, which we trust will not be necessary.

introduced a division of rights, which gives rise to great difficulties among landholders.

In order to show how irregularly this right is now divided, we may mention the instance of one of the richest commoners in England, who holds immense estates in the northern counties, and whose lead mines are among the most important in England. These lead mines are worked by him—1st. On property belonging to him, and of which he has the right of royalty;—2d. On property belonging to other individuals, but of which the right of royalty resides in him;—3d. On property belonging to him, but of which the royalty resides in other individuals, from whom he rents it;—4th. And, finally, upon lands, the royalty of which belongs to the Dean and chapter of Durham, while the exclusive right of the surface belongs to a third party.

Hence, it is evident, that the royalty in England has been but an additional right of patronage vested in the crown, and which has been used for no other purpose than to gratify the wishes of the favourites of the monarch. We may here observe, that the rights of royalty over every section of the country, have passed in this manner from the crown to individuals; the present king possessing the royalties of no mines except those vested in his person by virtue of his right of Prince of Wales and Duke of Cornwall.

Having shown the origin of the right of royalty, together with some of the arguments for and against its expediency, we shall proceed to examine a few of the many cases, in which an interference, on the part of legislative authority, seems to be justifiable. Our first example shall be taken from a case which was peculiarly applicable a few years ago, and would have continued so to be, if the hopes which had been formed of the existence of a valuable mine had not been disappointed.

Tin is a rare metal, but a very useful one. The only mines of it worked in Europe, are those of Cornwall, which are very rich and abundant; and those of Germany, which are comparatively inconsiderable. But the greater part of the tin used in the arts, and the best quality, comes from Ban-

ca and Malacca, and other mines in Asia; it all reaches Europe by the way of England. France possesses no tin mines. This metal is very useful in many of the arts, and particularly in time of war, as it enters largely into the composition of gun-metal. In case of a war with England, France has no means of procuring tin, except at a great expense, from Germany; but, in the event of a war with Germany and England, (as was lately the case,) France has no means of receiving any tin. Suppose a tin mine were discovered in France, and the individual on whose property it lay, from some motive or other, refused to work it himself, or to allow any other person to take advantage of it, would not the community at large be injured by this individual's refusing or neglecting to work his mine? might it not, in this case, be desirable that the power of disposing of the mine should rest in the hands of persons more apt to be actuated by the public welfare, than the isolated individual, whose patriotism is often stifled by private interest?

Again, there are, we believe, cases of a stronger nature in favour of some laws which would tend to facilitate the working of mines. Suppose a landholder find a mine on his property, and that he be disposed to work it; let it be, for instance, the same tin mine which we have just spoken of, and the importance of which to the community we have just established; but let us suppose, at the same time, that this mine could not be worked with advantage, unless a drift leading to a distant valley were opened, two or three hundred feet under ground, in order to drain the water. Suppose this drift have to pass under property belonging to other individuals, who, from some motive or other, would refuse to grant to the holder of the mine the privilege of opening his drift, unless he paid them an extravagant compensation, or perhaps will not agree to any terms. The motives of these individuals we do not examine; they may be actuated by groundless fears; perhaps by pique or jealousy at their neighbour's success; perhaps by disaffection to the country in which they live, if the mine be of sufficient importance to affect its political situation. Is it not evident, that in such a

case, society at large may be seriously injured, the holder of the mine may find himself ruined, and foiled in his attempt to carry on works of public utility as well as private advantage, by the mere selfishness or obstinacy of an individual, who derives no benefit whatsoever from this line of conduct, and whose property can by no means be injured by a drift passing several hundred feet under ground? Certainly no reasonable man could object to a law's being made which might benefit the miner in this instance, provided it were so restricted as not to prove oppressive in other cases.

A third instance in which the interest of the public may be at variance with that of an individual, and with our actual legislation, is, where a mine could be worked with advantage to the public and to the proprietor, if he were allowed to bring a stream of water to his works, in order to set his wheels in motion; but that this water could only be procured by means of an aqueduct passing over the property of his neighbours. In the case of a canal, the objections of the owners would be overruled; why should they not likewise be disregarded in a case which affects society perhaps to as extensive a degree? What objections could be made to a law securing to a miner the right of making such roads and aqueducts as are indispensable for his works, requiring, of course, at the same time, that he should pay his neighbours a full compensation for the injury done to their property, the amount to be ascertained as it now is in the analogous case of canals, &c.?

But there is another point to which we would call the attention of the *humane* legislator. It is one which we consider as of much greater importance, inasmuch as instead of the property, it is the life of many valuable members of the community which it concerns. Suppose a man, careless of the high moral responsibility which is attached to his situation as director of works of this nature, exposes the lives of the labourers whom he employs in dangerous works, which his ignorance or neglect has made him overlook, and which prudence and foresight on his part might have pointed out to him. Suppose an accident happen which he might

have prevented by a little attention, is such a director amenable before any tribunal? is there any law by which his presumption or his indifference can be punished? Will it be argued, that there was no compulsion on his part, and that the workman who perished was a victim of his own imprudence? will it be considered as a risk voluntarily encountered by the uninstructed labourer? and will society be satisfied with a verdict of "accidental death?" We fancy not; we hope not; we trust some measure would be found to teach this careless director, that besides being responsible to his Maker, he is answerable to his fellow-citizens, and to the laws of his country, for a waste of human life which he might have prevented.

Our object has been to show that there is good cause to inquire whether any law should be made, restricting or regulating the privileges of miners and landholders concerned or connected with mines. And if it is likely that such an interference on the part of the legislature shall become necessary, we think it would be of great advantage that the laws should have been made before the case shall arise to which they may apply. In this manner, we would avoid every thing like an *ex post facto* law. Should we neglect to make the law at present, when the art of mining has scarcely taken a footing in the United States, we may be called upon to make it at a time when it would be applicable to individual cases, and where its justice might be questioned. And let it not be said that we cannot make the law until the case to which it may apply shall have arisen and proved its necessity; for, in this respect, we may question the experience of Europe; we may see what cases have called for interference during the last five or six centuries, and be prepared to meet them when they shall occur in our own country. Another motive, which ought, we think, to induce the legislator to turn his attention to this subject is, that by so doing we will prevent the introduction of local usages and customs, which are at first introduced merely for convenience's sake, but which, after a while, assume the force of law, and tend to substitute, in the place of a wise, well digest-

ed, and universally applicable code of laws, a set of incoherent usages, often arbitrary and unjust, partial in their application, and not unfrequently, very contradictory; the history of the origin of laws in all countries, and especially of that upon mines in England, justifies us in our fears, that such would be the case in our own country, if the subject were totally neglected.*

Those who are opposed to interference on the part of the legislature, generally answer that it is useless, because individuals will always find it their interest to agree among themselves, and to work their mines, and to facilitate the working of those belonging to their neighbours; but we believe there are many cases, in which an individual may find it his private interest to oppose the general interests of society, and where he will do it if he can; we shall only bring one instance in support of our opinion, and we shall take it from the extensive and celebrated coal mines of Newcastle on Tyne; it is a well known fact, admitted by all those who have visited these mines, that some of them are very beneficial to the proprietors; others barely pay at the present price; while a third class cannot be worked without loss, under existing circumstances; if the causes of this disparity in the profits be inquired into, they will not, nine times out of ten, be found to exist in the nature or abundance of the coal, nor in the nature of the adjoining rock, nor in the quantity of water in the works, but chiefly in the local situation of the mine. Some of them are situated upon the banks of the Tyne, in such a manner, that the coal brought out of the pit is immediately emptied into the boats or ships in the river;

* Since writing the above, we have found a passage in Mr. Schoolcraft's work on the mines of Missouri, which proves that the evil which we apprehended is almost inseparable from mines, in a country where they are not regulated by law; and that it has already unfortunately taken root in this country. The passage to which we allude runs thus: "Custom has established a number of laws among the miners, with regard to digging, which have a tendency to prevent disputes. Whenever a discovery is made, the person making it is entitled to claim the ground for twenty-five feet in every direction from his pit, giving him fifty feet square, &c." (Schoolcraft's View of the Lead Mines of Missouri.—New York, 1819. Page 107.)

others are at a small distance, others again at a considerable distance from the river; but all could be worked with advantage, if the owners of the more distant mines were allowed to convey their coal to the river by the nearest route; but this they are prevented from doing, the owners of the intervening property refusing them the passage, or requiring from them such an extravagant toll, as often amounts to a prohibition. We have seen instances, in which the owner of the coal was obliged to make a circuitous road of eight or ten miles, where the real distance, by the shortest direction, did not exceed two or three miles. When we consider that these roads are all *made roads*, and *inclined planes*, it is impossible not to be struck with the great disadvantage under which mines at a distance from the river labour. The expense of making *railways* for such a distance, and the inconvenience of conveying so bulky an article as coal, and of so small a value compared to its bulk, deprive many owners of the reasonable profit which they ought to make, and prevent many others from working their mines. The effect is obvious; the great competition is destroyed; the public buys coal at an advanced price; and the owners of KILLINGWORTH and WALLSEND alone are benefited by it.

In making laws on mines, we must bear in mind, that they differ much from agricultural property, in this especially, that they are of a *perishable* nature; that the mine which flourished during the last century, and offered great expectations to the miner, has been exhausted; that it exists at present only in the remembrance of the great profits which it afforded, and in the immense chasms which it has left behind.

As respects the interests of the miner, we may say, that they are closely connected with those of the manufacturer, in the same way that there is an analogy between mines and manufactures; because they both have alike a tendency to convert the imperfect and native material into a new substance, better adapted to the wants of man; they change its form and its texture, its external and internal characters, and by a variety of manipulations, they produce a new body; the interests of both are in a great measure linked together;

both require the fostering hand of government, both demand the attention and protection of the rulers of the state, both tend to increase the national independence, and to create a new source of wealth and prosperity; the miner extracts, from the bosom of the earth, the metals which the manufacturer converts into the tools and instruments used in daily life, and again receives from the latter those products of human ingenuity, without which, he could not continue his subterraneous works; both the miner and the manufacturer can be greatly assisted, or much injured, by the transactions of the merchant; both can assist him in his undertakings, and benefit him in his speculations; but both are at his mercy; he can bring a temporary ruin upon them, which must, however, always recoil upon himself, and involve him in their common misfortunes.

Hence, although the property of the miner may resemble that of the landholder, his interest connects him with the merchant and the manufacturer.

Before we conclude this section, it remains for us to determine the importance of mining, compared with other arts, and on this subject, we trust, a few words will suffice.

It is evident that this art is of the first importance, since it may be considered as the basis of all other arts, inasmuch as these require the previous success of the miner, in order to provide for them their first implements, since society could not exist without the use of the metals, salts, and fuel, derived from mining; since civilization is essentially connected with it, and must have originally been dependent upon it, for every improvement which it has made.

Let us take any art we please, and inquire into the nature of the first materials it uses, the tools which it requires, the products which it consumes, the operations it performs; let us then abstract every material produced by mining, &c. and let us see what will remain; we believe we may safely aver, that it will be "*stat nominis umbra.*"

SECTION THIRD.

Of the actual state of Mining in Europe. Of the advantages which might accrue to the United States from the introduction of this Art. Of the obstacles which would intervene, and of the best course to be followed in order to remove them.

The traveller who returns from distant countries, and who wishes to make known the result of his observations abroad, is seldom received by the public with indulgence. It is difficult for him not to attack opinions already entertained by some of his readers. Hence, his observations are weighed with an unusual degree of severity. Every remark which he makes is closely examined, and he may indeed deem himself fortunate, if, in the review of his opinions, his intentions are respected, and his motives are not made the subject of scrutiny. If the observations he makes are of a favourable nature, he is often suspected of wishing to assign to his travels an undeserved degree of importance. His praises are said to be lavished indiscriminately. The correctness of his judgment is questioned. If, on the contrary, he censures or ridicules, he is himself blamed, and not unfrequently by the very same class of readers who would have condemned his praises. He is represented as presumptuous, especially if he happen to be young; his censures are considered as the mere effect of prejudice; he is accused of being partial to one nation at the expense of another.

We do not flatter ourselves that our remarks upon the actual state of mining in Europe, will deserve or meet with a more favourable reception; but we solicit the indulgence of our readers on this subject, as we believe it is the first attempt of the kind which has been made, and that the subject is new to the greater part of our fellow-citizens.

We propose to examine, in the following pages, the state of the miner's art in France, Switzerland, Savoy, Germany, the Netherlands, Scotland, and England, as we have visited those countries, and have paid particular attention to the pre-

sent subject. We shall add a few remarks upon the mines of such other parts of Europe as we have not visited ourselves, but concerning which we have obtained correct accounts from fellow-travellers, upon whose accuracy we might depend.

Mines of France. Until the end of the last century, the mines of France had been neglected: the government had either overlooked the subject, or been induced to suppose that the mineral wealth of that empire was but inconsiderable. The first attempt to improve the art was made, we believe, in 1740, when the government defrayed the expenses of two intelligent travellers, (Messrs. Jars and Duhamel,) who visited the mines of Germany, Sweden, and England, and one of whom wrote a series of interesting memoirs on these mines, which were published after his death, and are considered, even at present, as among the most valuable text books on metallurgy.* A second expedition of the same nature was fitted out during the few years of comparative calm which marked the early part of the reign of Lewis XVI. All the travellers who shared this expedition have since died, except the distinguished author of the "Siderotechnia,"† a work which contains all that was known of the art of making iron and steel, up to the time of its publication. But the most important step, taken in France, to improve the art of mining, was undoubtedly the establishment of a School of Mines. This school was founded a few years before the revolution broke out, but it was only brought into activity under the republican government, to which is also due the institution of a periodical work of great merit, exclusively devoted to this art, and to the sciences connected with it.

The School of Mines was opened at first in Paris, and its original professors were among the most distinguished men of the time. After the conquest of Savoy, and its union with France, the school was removed to Moutiers, in the Alps, not far from Mont Blanc, and a neighbouring lead mine, of some importance, was placed at the disposal of the directors

* Voyages Metallurgiques par M. Jars.

† La Siderotechnie ou l'art de traeter les minerais de fer, par J. H. Hassenfratz.—Paris, 1812, 4 vols. 4to.

of the school. The object of this removal was to enable the students to become acquainted with the practical part of the art, at the same time that they studied its theory. This school was in reality a nursery of good miners. The number of engineers of mines which it has produced, and the celebrity which many of them have already acquired, while others have been employed in as useful, though less brilliant a career, are the best proofs that can be given of the merits of this institution.

On the return of the Bourbon dynasty to their paternal throne, the new acquisitions were given up, and Savoy returned to its ancient masters. The School of Mines was necessarily broken up; it was a short time after re-organized, and located in Paris. The situation in the metropolis was considered, in many respects, more advantageous, on account of the great facility which Paris affords over all cities, for the pursuit of science. The lectures are delivered by able professors, whose courses last during the winter season: an excellent chemical laboratory is annexed to the institution, in which the students are enabled to enter as deeply into the science of docimasy as their inclination prompts, or their talents permit them. The school possesses, likewise, a superb collection of minerals, an excellent library, a cabinet of models of the machinery used in mines, &c. Teachers of drawing, and the German language, have been added to the school, and an instructor of the English language was also in contemplation, and has probably been already annexed to the institution. During the summer season, the students travel; their excursions are directed by the professors; they are generally sent to some mine, where they spend several months in acquiring a practical acquaintance with the operations, the theory of which they have been taught in the winter lectures. This method of dividing the year into two parts, one of which is devoted to the prosecution of the scientific branches, while the other is employed in acquiring practical experience, offers great advantages, though probably not so many, upon the whole, as the method followed at Moutiers, and which has been adopted in the academies of mines in

Germany. The choice of students is an object strictly attended to. The students are divided into two classes. The first consists of young men receiving a salary from government, and who are destined to supply vacancies in the corps of mining engineers. It is indeed for these that the school was established: but a second class has been added, consisting of such young men as are desirous of acquiring a knowledge of the art, with the expectation of afterwards superintending works of their own. Their number is limited; and they are obliged to undergo an examination before their admission. The royal students are taken from those who have completed their studies at the "Ecole Polytechnique," the best mathematical school in the world. They are generally selected from those who have distinguished themselves most in that seminary.*

Such is the actual state of this institution, which, under the care of its present directors and professors, cannot, we think, but rise to a great degree of eminence, and effect great improvements in the art of mining in France. We have perhaps dwelt upon this subject longer than it deserved; but we could not pass slightly over an institution in which we have studied the rudiments of our profession, and met with the most flattering marks of kindness and attention from the

* Besides these two classes of students, established by law, there are a few foreign students who have been admitted by special permission granted by the Director general of mines. The extreme liberality with which the French government extends gratuitous information, not only to its own subjects, but also to every foreigner who visits Paris for the purpose of study, has often been noticed and eulogized by travellers. To the many instances already recorded, we would add the following. We arrived in Paris in 1817, a short time after the re-organization of the school, and very readily obtained the favour of attending the lectures and of studying in the laboratory of the school; in a word, we enjoyed all the privileges of the royal students, without being obliged to obey the regulations by which they were governed. Since that time, they have received, in the space of four years, eight foreigners; four of whom were from the United States, one from Peru, one from Switzerland, one from Poland, and one from Italy. The four from the United States were all from Pennsylvania, and three of them are Philadelphians. The time which most of these continued attached to the school was from two to three years, and all were allowed to remain as long as they chose.

distinguished professors and directors of the school. With many of the students we have contracted friendships which will ever render the School of Mines of Paris the source of pleasant recollections.

The mines in France are generally worked with great talent and regularity. They are not all as profitable as they might be; but this is owing to causes which are quite independent of the miner's control. A deficiency in canal and river navigation, which prevents them from sending off their products in every direction, as they would do if the modes of communication were easier, is undoubtedly one of the greatest impediments to the success of mining in France. The second cause which operates to diminish their profits, arises partly from the national character and partly from the want of capital. It is seldom that one can see in France the public spirit which we admire so much in this country, but the effects of which, we believe, are no where so conspicuous as they are in England. Every institution in France seems to prosper but little, unless specially protected by government; but even that protection cannot avail them much, for it introduces a system of favour and monopoly which is always injurious to the best interests of the manufacturer and the merchant. It is one of the most striking characteristics of continental Europe, one which always calls forth an expression of surprise from an American or Englishman, that there exists on the continent no canal or road companies, no associations for internal improvement, in a word, but few companies created for the purpose of carrying on works of national importance, by which they themselves may be benefited. If the traveller expresses his surprise at this apparent indifference and want of energy, he is ridiculed, his plans are considered as visionary, and compared to the famous bubble of *Law* under Lewis XV. or to the *assignats*. A want of confidence in associations similar to our incorporated companies, has prevented their success, and must be considered as having severely affected every branch of public economy, and none perhaps more sorely than that of mining.

In mines, France is not deficient; and if every discoverer of a mine were well rewarded for his trouble, and capitalists disposed to unite and work them, we have no doubt, that in ten years' time, the mining establishments in France would have doubled both in number and importance. Something is certainly doing in that way at present, as was proved by the creation, in 1818, of a company, with a capital of about three hundred thousand dollars, for the purpose of working the iron ore of the coal mines of St. Etienne, by means of coak, in the same manner as the English work their clay iron stone, from which they extract their best castings.

France abounds in coal of the very best quality. From a map inserted in the "Journal des Mines," Vol. XII. it would appear, that out of the eighty-three departments into which France is at present divided, there are forty which afford coal. The principal coal fields are near Valenciennes, in French Flanders. These mines all belong to one company. They raise coal by twenty-two pits, from a depth which varies from six hundred to sixteen hundred feet. The population in the neighbourhood of the mines, and receiving its support exclusively from them, amounts to upwards of four thousand five hundred inhabitants. The company divides the profits every year. They are said to exceed two hundred and fifty thousand dollars annually. It is difficult to state upon what capital they work. The original stock was inconsiderable, but has been gradually increasing, by improvements made with money arising out of the profits of the mine. The money advanced at first did not probably exceed the annual interest at present yielded to the stockholders. The actual capital is a thing very difficult to ascertain, because it varies every year. For instance, they are obliged, every other year, to sink a new shaft, which costs about forty thousand dollars. From some documents which we have seen, it would seem that the profits (if they have not been overrated) amount to about thirty-three per cent. of the quantity of coal sold annually. These mines are, we believe, among the most interesting and best directed that we have seen. The great regularity with which they are worked

prevents many accidents; and the able and deserving director* of this establishment unites sufficient theory to the experience of many years, to enable him to conduct with facility one of the largest and most important concerns of which the art of mining can boast.

Next in importance to Valenciennes is the coal field of St. Etienne, near Lyons. The coal is here also of a very good quality. It is not worked to so great a depth; but, instead of being worked by a single company, it belongs to a great number of small proprietors, who work it each on his own account and in his own way. This causes a great waste of coal; accidents are more frequent; and the mines will be rendered unprofitable much sooner. One advantage, however, which this method produces, is, that it establishes a competition useful to society, and that it destroys the monopoly which exists at Valenciennes. The abundance and cheapness of coal here has had the same effect as in England. St. Etienne has become one of the first manufacturing towns of France, and bids fair to become a second Manchester or Birmingham. Some of the finest ribands, silks, and velvets, of France, are made in this town. Should the company we have already mentioned succeed in its attempt to work the clay iron stone, this city will acquire an immense increase of trade and prosperity.

Besides these coal mines, the French have others in various places, as at Ingrande upon the Loire, at the Creusot, at Litry in the north of France, &c.

* M. Mathieu, the present director of these mines, had the good fortune, when under-director, to rescue from death fifteen of his fellow-citizens. Having heard that a party of miners had been working in a part of the mine, where the air was very foul, and that they were perishing from want of fresh air, but that no one would venture to go and relieve them, he without hesitation hastened to the dangerous spot, and brought out one of the unfortunate victims. Encouraged by his success, he renewed his generous effort, and succeeded in bringing out fourteen safe; but in his attempt to rescue the fifteenth, he himself, being exhausted with fatigue, and choked by the foul air, fell almost lifeless, and was with great difficulty restored to a life the remaining part of which must be blessed by the recollection of his heroic deed.

With iron, the French are also well supplied. Their principal ore is the *bog ore*. The furnaces are numerous, and generally are of similar forms and dimensions. There are few iron works on a very large scale; for the most part, they are subdivided into small properties. Their best works are in the centre of France, in the *cidevant Province du Berry*.

The clay iron ore has as yet been worked in no part of France, that we know of. Some attempts made in 1817, at Valenciennes, were successful; but the quantity of ore not being sufficient to render it an object worthy of attention, the working of it was abandoned. The quantity at St. Etienne will, it is believed, be more considerable.

The sparry iron ore is worked in the *Comté de Foix*, and principally in the department of Isere, where the furnaces of Allevard enjoy a well-deserved celebrity, and are well worth being visited. An attempt was made to work these ores in the Catalonian furnace, in which the ore is reduced by a single operation into metallic iron. It is said, this method had answered very well, near Avignon. The first attempts at Allevard were successful, but afterwards the iron produced was found to be of a very inferior quality. When we visited the works, this furnace was not in operation, owing to the pecuniary embarrassments of the owner. Since that time, we have understood that the works had been resumed, but with what success we know not. It is probable that it requires some skill and a great deal of care on the part of the workmen, who, if not strictly watched, are very apt to be inattentive; and the quality of the iron is easily affected by the slightest neglect on their part.

Charcoal is almost the only fuel used in the iron works: it is often a very expensive article, and no doubt coak could be substituted with great success and great economy in many cases. The consumption of iron in France exceeds the quantity manufactured, a great quantity being annually imported. The castings are tolerably good, though very inferior to the English. Their iron varies much in quality, but their best cannot stand a comparison with the Russian or Swedish iron.

This inferiority is probably owing to the quality of the ores, which are seldom entirely free of iron pyrites, or copper ore, besides some phosphate of iron.

The specular iron ore is worked near Framont, and affords employment to upwards of two hundred workmen. Cabinet specimens of this ore are found in this mine, equal in beauty to the Elbese iron ore, and are highly prized.

With lead, France is not very abundantly supplied. Several mines which were formerly worked, in Britanny, have been abandoned; and there remain in that province at present, but the mines of Poullaouen and Huelgoat, which are worked by one company. These mines are tolerably rich in silver, at least that of Huelgoat, which contains sometimes in the pure galena as much as $\frac{16}{10000}$ of silver.

The quantity of silver and lead annually produced is considerable; the profits resulting from it have varied. At times they are very considerable, then again very small; and, at other times, these mines have proved to be a losing concern. The mines are at present in a very flourishing condition, and bid fair to rise in importance and profit, under the care of their present director, Mr. Juncker, an engineer of mines of fine talents, who has already introduced several valuable improvements in the manner of smelting and dressing the ore.

Besides these, there are lead mines in the south of France. Those in the department of the Lozere, are important on account of the silver which they contain. At Vienne, not far from Lyons, the lead ore is worked by a new metallurgical process, which consists in smelting it with old iron castings in a reverberatory furnace of a particular form and construction.

In copper, France is at present very deficient; there exist, to our knowledge, but the mines of Chessy and St. Bel, near Lyons, both of which are owned in part by, and are under the direction of, M. Jars, a near relation of the celebrated author of the "Voyages Metallurgiques." The mine of St. Bel is worked upon a considerable vein of pyrites, the average richness of which never exceeds 5 per cent.; general-

ly about 3 per cent. At Chessy they have worked a similar vein, but their attention has been, for the last few years, engrossed by a rich deposit of carbonate of copper, both blue and green. It is this mine which has yielded those superb specimens of azure copper ore which have so justly excited the admiration of all those who have seen them.

More lately, they have been working a black ore, the nature of which had not been exactly ascertained, but was supposed to be a mixture of copper pyrites, and oxide of copper. A very interesting paper on the nature of this ore, and on its composition, has appeared a short time since in the "Annales des Mines," for 1820. The paper is by M. Thibaud, engineer of mines, with notes by Professor Berthier; it is calculated to throw much light upon the subject of copper ores in general, and the new products formed in copper furnaces.

The quantity of copper produced annually by these mines is but trifling; but the quality of the copper is remarkably good.

The French work mines of antimony in Auvergne. The veins of this metal are very abundant, but the quantity required in the arts being small, they have not been worked to any great extent, or with much regularity; there has been a great waste of ore. The French export a considerable quantity of antimony.

Gold, silver, and tin, are not worked in France. Specimens of these three metals have been found, and the two first were worked before the French revolution, but they have been abandoned as unprofitable. Tin ore has been found within only a few years past. It was discovered in two different points: the first near Limoges; the second not very far from Nantes. In both places the administration of mines caused some money to be spent in works to ascertain the extent of the deposit, but no satisfactory result was obtained. Near Limoges, old scorias and slags have been found, which prove that this mine had been worked at some very distant epocha, which is supposed to have been prior to the conquest of Gaul by Julius Cæsar. In the year 1818, about

2000*lbs.* weight of metallic tin, of a very good quality, was obtained from the ore mixed with the sand, on the sea-shore near Nantes. It is an interesting fact, that the mine of Limoges presents all the geological characters of tin mines in other countries. That of Nantes has, in like manner, offered the most important characters, but not the interesting and hitherto constant association with *wolfram* and *arsenical pyrites*, &c. There is, therefore, reason to believe, that if this mine could be worked with advantage, it would yield tin of the first quality, as it is associated with no other ore than magnetic iron ore, and that the iron might probably be easily separated during the metallurgical operations, if not previously washed out of it.

Zinc exists in France, but only in combination with sulphur. It has been ascertained that this ore (the Blende) could be used in the making of brass, &c.; but the French find it more advantageous to import the calamine from Belgium.

Mines of salt were formerly unknown in France, but within the last three years a very rich and extensive bed has been discovered in the eastern part of France, and promises to be very profitable to the undertakers. It was accidentally discovered in 1819, by persons who were boring for coal.

Mines of Savoy. Savoy is not as rich in mines as from its rugged and mountainous aspect it might be expected to be. It possesses, however, many important mines of sparry iron ore, some of which have been worked for upwards of five centuries. The most interesting mine which the country presents, is the lead mine of Pesey, an establishment which does the greatest honour to the French engineers, under whose direction it arose to an unusual degree of splendour, during the time that Savoy was united to France. It still continues to flourish under the care of an able director, to whom the Sardinian government intrusted it after the cession of Savoy.*

* If we may be allowed to introduce here a few remarks upon the great advantage of uniting theoretical knowledge to practical experience, we would observe, that it is by the application of theory in a prudent and skilful manner, that the mine of Pesey arrived at its present degree of importance.

A copper mine has been worked near St. Georges. The ore is a pyrites, and is found in the same veins with the sparry iron ore, or in veins which intersect them. A very interesting mine was discovered at Servoz, in the celebrated Valley of Chamouny; the ore has in many respects the character of a grey copper ore; it has been abandoned from the difficulty of smelting it. It is probable, that if the French School of Mines had remained in the Alps, some method to smelt the ore would have been discovered, and we must regret, for the sake of science, that this mine should have been abandoned; we have, however, heard that one of our late fellow students, at the School of Mines, had some intention to undertake to work it, and we sincerely hope that he may succeed, both on his own account, and for the interest of metallurgy.

Mines of Italy. Italy is but poor in mines; it contains no metallic mines of any note. The gold mines of Macugnaga consist in iron pyrites, containing a very small proportion of gold; they are not profitable. The mines of alum at the Tolfa, near Naples, are celebrated and interesting. The island of Elba is famed for its specular iron ores, which are worked on a very large scale, and with success.

Mines of Switzerland. Switzerland presents now but little interest to the miner; the salt mine of Bex, near the lake of Geneva, is, however, an object well worthy of his attention; at this mine there exist some of the finest and most interesting works which we have ever seen, and they are remarkable for the nicety and correctness with which they are executed.

Lead has been discovered in several parts of Switzerland, and a party of Saxon miners left their country last spring, with a view of undertaking to work it.

When this mine was first intrusted to the French "Conseil des Mines," the lead extracted from the ore did not exceed 27 per cent. By gradual improvements, introduced with caution and science, the product obtained by them rose, in a few years' time, to 73 per cent. which is the maximum of what that ore can yield.

Mines of Germany. We now come to a country in which the art of mining has been prosecuted for many centuries, with a degree of attention and scientific knowledge, which was not possessed in other countries. In Germany, mining has been considered as one of the most important and most honourable professions; it has received the peculiar notice and favour of the sovereign, and has been carried to a pitch of excellence almost inconceivable; every thing has been reduced to rule; if we were not convinced that the German is an essentially mining nation, we should acquire this conviction by examining the state of the art in their country; by tracing its progress from the earliest days; observing how anciently it flourished in Germany; what numberless discoveries have been made in that country; what distinguished professors in this art it has furnished, &c.

There may be said to be in Germany five great centres of mining.

1. That of Freyberg in Saxony; this comprehends all the silver, lead, and copper mines, in the immediate neighbourhood, which support a population of about ten thousand inhabitants; also, the silver, tin, and cobalt mines of Annaberg, Altenberg, Zinnwald, Schneeberg, Marienberg, &c. in Saxony; and those of Joachimsthal, and Johann Georgen Stadt, in Bohemia.

The whole population of this district, comprised in the "Erzgebirge," or ridge of mountains which separates Saxony from Bohemia, depends entirely upon mining for its means of subsistence. This district is one of the most interesting to the miner; it furnishes silver, lead, copper, tin, iron, cobalt, arsenic, and coal. It is quite limited in its extent; the population supported by the mines exceeds forty or fifty thousand inhabitants. The produce in silver is considerable; that of Saxony alone, amounts annually to about fifty-four thousand marks, or about twenty-seven thousand pounds weight; the value of which exceeds half a million of dollars; the lead is likewise considerable; copper is much less so; but tin is a very important item; this is the only place on the continent of Europe where tin ore is worked; and

though the quantity furnished is inconsiderable, when compared with that produced by the Cornish mines, still it must be considered as one of the greatest sources of wealth which this country possesses.*

Iron is worked with advantage in some parts of the Erzgebirge, but in this respect the Saxons are far inferior to their neighbours, the Prussians. There are no cobalt mines in Europe besides those in Germany, and among them those of Saxony and Bohemia deserve particular notice; the finest smalt known, is that produced by the Saxon cobalt.

There are three coal fields of some importance in Saxony, but which are not worked with that degree of science and activity which we have a right to expect from German miners. If we inquire into the causes which have given so much celebrity to the mines of Saxony, we will find that it is due more to the care and patronage which they have received from the nation at large, than to the intrinsic wealth of the mines themselves; at least, it is certain, that nothing short of the wise regulations under which they are now governed, could have prevented them from sinking into insignificance; for the great depression in the value of silver, since the discovery of America, and the resulting great increase in the price of materials, labour, &c. have changed the relative proportion of the produce to the expense, and made these mines, which were at one time the envy of all the sovereigns of Germany, and a source of constant discord among the princes of the house of Saxony, an object of comparatively little profit. If we are to credit the historians, the princes of Saxony were noticed and envied even by the emperor himself; so great was their display of wealth and splendour in all the public ceremonies and tournaments of the middle ages.

In Saxony, the art of mining has been raised to the rank of the most honourable profession; the sons of the proudest noblemen of the land do not consider it as unworthy of their

* The tin mines of Monte Rey, in Spain, were never very considerable, and are, we believe, almost entirely abandoned. Those of Portugal have long since ceased to be worked.

attention to go through the regular studies, and perform the same task as the common miners, in order to prepare themselves for the higher offices. The common miners have great privileges and marks of distinction; they are exempt from militia duty; they wear an uniform of their own, the same which has been worn for the last five centuries; they have days of festival exclusively their own; it is in this manner that they have been made to cherish their profession; nowhere have we seen so great an *esprit de corps* as subsists among them; in the "Erzgebirge," their manners and customs, even their language and expressions, have all a connexion with the art which they so highly honour, and which has been professed by fathers and sons for centuries.

The Academy of Mines of Freyberg was established about the year 1760; it has acquired a great reputation all over Europe, and especially in Germany: the name of Werner tended to increase its fame, and long supported it; since his death, his chair has been filled in a manner highly satisfactory to all the true friends of science. The great advantage which the Academy of Freyberg can boast of is its situation; in the immediate neighbourhood of this city, there are one hundred and thirty mines, to all of which the students have free access, and which they are even invited to visit; so that a constant field for observation is presented to them, and a great mass of practical information may be acquired in a short time. The students of government have a regular task assigned to them in the mines, like common workmen, and which they are obliged to perform; in this manner they become familiar with the use of the tools of the miner, &c.

2. The second great mining district of Germany is that of the Hartz, in the kingdom of Hanover; the mountains of the Hartz present a deposit of nearly the same importance and value as that of the Saxon ridge; the mines are exclusively silver, lead, and copper; lead is the most important produce of these mines: the administration of mines in this district is generally pointed out by the German writers as a model for imitation. Great powers are vested in the sove-

reign, and, through him, in the officers of mines; the mines have been worked since the eleventh century, and are still in a highly flourishing condition. Like the mountains of Saxony, this country was peopled by colonies of miners; and if it were not for the mines, the population would be unable to support itself there. They would be obliged to remove to more fertile regions. The mines of the Hartz are particularly interesting, on account of the great perfection to which the dressing of ores has been carried, and for the able manner in which some of the mines are worked, with the assistance of fire, or torrefaction—principally that of the Rammelsberg.

3. The third district of mines which we shall notice, is that near Siegen, on the Rhine. It now belongs to Prussia, and is rich in mines of lead, copper, iron, zinc, cobalt, &c. These mines have already attained a great degree of importance; and, under the active and vigilant direction of the Prussian Council of Mines, they promise to increase rapidly in importance and extent.

4. The fourth district is that of the *Mansfeld*, which formerly belonged to Saxony, but now forms a part of the kingdom of Prussia. It contains many rich works of copper, valuable by the silver contained in it, and remarkable on account of the manner in which they are conducted. The ore, being in a bed whose thickness is but trifling, requires a peculiar manner of working it. The miners are obliged to lie flat upon the ground, resting upon their left side, or upon their stomach. In this difficult posture, they work with their right arm, and make excavations which do not exceed twelve inches in height. This method, which is termed the "Krumm Hals Arbeit," is very laborious and fatiguing, and nothing but early habit could enable a man to work in mines of this nature. The object, in making such small excavations, is to avoid the expense attending the making of larger ones, and of propping them up when made.

5. The fifth mining district of Germany is in Silesia, one of the richest and most fertile countries in Europe. It belongs to Prussia, and the present state of Silesia does honour

to its government. The mines here are principally coal, iron, and lead. The iron works are said to be almost unequalled in any part of the world for their beauty; they are on a very large scale; that of Kœnigshûtte is the most celebrated; their castings are of the very best quality; the coal mines are important, and in number exceed one hundred; the coal is coaked, and used in the smelting of their iron. We have seen articles executed at the Berlin works, with the pig iron from Silesia, which, for their beauty and finish, exceed any thing ever cast in iron even in England. A number of small ornaments, such as rings, necklaces, eardrops, &c. have been made there, which equal any similar article of female dress.

Lead exists at Tarnowitz, in a bed presenting very interesting geological features.

Besides these five great mining districts, there are, in Germany, many other places worth visiting, and very important to the miner. Among these we may mention the iron and steel works of Styria and Carinthia, in the Austrian dominion, where the best German steel is made. The important quicksilver mines of Idria, which have often supplied the silver mills of America with mercury, when the mines of Almaden in Spain could not do it; also, the mercurial mines of the Palatinate and the Dutchy of Zweibrûcke, (Deux Ponts,) which are now annexed to Bavaria.

With salt mines, the German empire is well provided. We find in it the rich country of Salzburgh, which owes its name to the valuable deposits of salt which it contains.

To this long list of interesting mines, we may add the copper and cobalt mines of Riegelsdorf in Hesse Cassel, the rich cobalt mines of Thuringen, &c.

We might lengthen out this enumeration of German mines, for no country is so rich in mineral deposits as this empire; but besides these, it enjoys all those of the countries annexed to it, which form no inconsiderable part of the wealth of Austria and Prussia, viz. Hungary, Tyrol, Poland, &c.

Hungary is celebrated for its gold mines, the only mines of this metal, worked with any kind of advantage, in Europe. If it were not for the great care given to the washing of the

ore, and the scientific disposition of the tables used for that purpose, these mines could not be worked.

The salt mines of Poland and Hungary are proverbial.—The names of Wieliczka and Bochnia are familiar to all.

The mines of Germany are more remarkable for the regularity with which the operations are carried on, for the scientific disposition given to the works, for the length of time that the mines are kept in activity, than for the wealth which they produce, or the profits which they afford. In the mines of Germany, we admire more the works of man than the gifts of nature. If it be observed, that their mines yield but little or no profit, we reply, that were it not for their great improvements in the art of mining, they would long since have been compelled to abandon them—that no nation, that we are acquainted with, could have worked these mines as the Germans have—that it is to the persevering, industrious, and saving character of the German nation, that we are to ascribe the success of their mines, and (however disagreeable they may be to our general ideas of individual rights) it can not be disputed, that it is to the wisdom of their laws that we are to assign the present flourishing state of their mines. We have heard some travellers, who took too superficial a view of the subject, scoff at the character of the mining institutions of Germany, and ask what advantage a nation derived from mines which were not profitable in a pecuniary point of view? To this we would reply, by asking if it be of no advantage to Germany to be able to extract from the bowels of the earth, not only metals enough for her own consumption, but even for exportation? If it be of no advantage to the German empire, to be independent of all its neighbours for the most useful materials required in the arts? If it be of no advantage to be able to coin, every year, nearly two millions of dollars' worth of precious metals, derived from its own soil? If there be no advantage in supporting a population of upwards of a million of inhabitants, which otherwise would be without employment? If the country is not benefited by finding means to support this population, upon cold and rugged hills, whose barren soil could never be fertilized by agricul-

ture? If there be no advantage in consuming the timber, which would otherwise grow to no purpose, on the summit of those uninhabited mountains? In deriving benefit from those numberless springs and streams of water, which are now made subservient to the uses of man, and which otherwise would flow in useless and undisturbed tranquillity, like the great waters of our western wilds?

The traveller who, after having duly weighed all these questions, can unhesitatingly give an unqualified negative to the whole, may indeed be justified in ridiculing the simplicity of the German miner, who works his mines although they yield him no great dividends; or in asserting that there are no advantages resulting to the country from the working of these mines: but until he can satisfy us that he has fairly examined the subject, and that he is fully qualified to decide the question, we may be justified in drawing a different conclusion, and tax him with indiscretion and levity, while we admire the industry and wisdom of the German nation.

Mines of the Netherlands. The kingdom of the Netherlands is divided into two parts, one of which contains no mines whatsoever, while the other is very well supplied in this respect. Holland, or the old Seven Provinces, is a country which affords not the slightest interest to the miner; while Belgium may well deserve his particular attention.

The principal mineral wealth of Belgium lies in its coal mines, which form a continuation of those which we indicated as existing at Valenciennes, in France; but as they run over a much larger country here, so are they much more important and extensive. The principal centres of the coal mines are at Lieges and at Mons. They are worked with great talent and economy; but the difficulties are numerous. These works having been commenced at a very remote period, when the art of mining was in its infancy, the first excavations were made in opposition to the best methods now in use. Large vacant chambers were left, without any precaution being taken, not even a correct survey of them being made. These wastes, in the course of time, have become filled with water or foul air; and, as their situation is not

well ascertained, the miners of Liege are obliged to keep a good look-out for them; for if they were unexpectedly to meet one of these excavations, there is reason to fear, that in many cases the division of miners thus surprised would either be drowned by the immense volume of waters which would rush out upon them, or be choked by the no less rapid stream of foul air. There are many instances on record, in which whole parties of twenty, thirty, or even more miners have found their doom, in a space of time too short to allow of any relief or assistance being given them. The usual method of looking out for these chambers, is by boring horizontally in various directions, as the miner progresses in his work. Some of the coal mines of Belgium are as dangerous, on account of the foul air, as the celebrated mines of Whitehaven, in England; but we believe that since the introduction of Sir H. Davy's safety lamp, only one accident has taken place, and that through the carelessness of a workman, who opened his lamp in the midst of the foul atmosphere, notwithstanding the strict orders he had received to the contrary. If the province of Belgium were as well provided with canals as her sister state Holland, those mines would receive additional importance; but notwithstanding that the country is level, the carriage of coal is very expensive, on account of its bulk; so much so, that in Antwerp, English coal from Newcastle can be sold, and is actually selling, cheaper than the coal of Belgium.

Next to the coal mines in importance are the mines of zinc at Limburgh, not far from Aix-la-Chapelle. This is the richest deposit of calamine known to exist any where. The works have been carried on without any great regularity; yet they promise to last much longer. The zinc is reduced to the metallic state at Liege; but the greatest part of the calamine is carried off in its original state, having been merely picked and roasted: it is thus transported to other parts of the kingdom, where it is converted into brass, and a great proportion is exported for that purpose. The brass is made in Belgium by smelting the copper with the calamine and coal in a crucible. It is of a very superior quality. We

have seen some of these brass works in Namur, where the business is carried on, on a large scale, and in a very profitable manner. The iron works of Belgium likewise deserve to be mentioned. They are situated on the Meuse, near Namur. Their ore is the bog iron ore; their fuel, charcoal. Their castings are very good. It is probable that coak might be used here with advantage and with great economy. The building stone which they use for their furnaces is remarkably good: we saw a furnace there which had been in operation for nearly three years without interruption, and it appeared by no means to be injured, nor to need any repair.

Besides these, there is in Belgium a valuable lead mine, at Vedrin, near Namur. We believe it contains no silver whatever, although we find it stated by a highly respectable author,* that it yields annually seven hundred marks weight of this metal; but we apprehend there is an error on this subject. This lead mine has been considerably improved of late, both in the dressing and smelting of ores, also in the machines to drain the water. A pressing machine, on the most approved plan, has been introduced into the mine. The fall of water is about three hundred feet. In the dressing of the ores, they have substituted for the old system the shaking tables, which are very advantageous; and, finally, in the smelting of the ore, they have abandoned the old form of the furnaces, and have substituted the reverberatory. All these improvements have been made by a single man, M. Bouësnel, director of the mine, late French engineer of mines, and now an engineer of the *Waterstaat*, in the service of the king of the Netherlands: they are very creditable to him.

Mines of Great Britain. We now proceed to treat of the mines of Great Britain, a country more interesting to us than any other, on account of the great analogy between our manners, laws, and institutions, and those of the mother country. Whatever may be the views or the object of the traveller in Great Britain, he will always find himself well

* M. De Bounard—Dictionnaire des Sciences Naturelles, article *Mine*.

rewarded for his trouble. He will always find much to admire, much indeed which he would look for in vain in any other country. This remark, which we believe to be applicable in general cases, is peculiarly so in mining. In no country are the mines as flourishing, as important, and as productive, as they are in Great Britain. Distinguished as the British nation is, for that peculiar talent which they possess to so eminent a degree, of inventing and improving upon every thing, and gifted as they have been by nature, with a remarkably great share of public spirit, much greater than that of their European neighbours, it was impossible that mining should not meet with encouragement among them, and, if once encouraged, it was a necessary consequence, that in their hands it should rise to the highest degree of perfection.

When we consider the nature of their mines, their antiquity, the difficulties which they had to encounter, the manner in which they overcame them, the great improvements which they have made in the machines of mines, and in the metallurgical operations, we are justified in asserting, that the British nation is certainly that in which the art of mining is at present the most flourishing. It is true, to them nature has been most bountifully liberal. No country that we know of is possessed of such rich and extensive deposits of coal as the north of England. Nowhere has the best quality of iron ore been more universally spread over a country than over England. Nowhere have tin and copper been found in such abundance as in Cornwall, where they have been worked for so long a time that many authors are inclined to believe Cornwall to have been the celebrated Cassiterides islands, whence the Phenicians are said to have procured their tin. Scotland is no less distinguished for her mines than England. With coal the Scotch are abundantly supplied; and it is of so excellent a quality, that we have heard them assert, (with what truth we know not,) that their coal was preferred to the best Newcastle coal, in the London drawing rooms. Their coal mines exist in all the south of Scotland, and cover an extensive tract of land in the neigh-

bourhood of Edinburgh and Glasgow, extending from the Frith of Forth to the Clyde; also in Fifeshire, &c. Scotland likewise boasts of her iron works, and this with justice. The largest, and most profitable in the world, are the celebrated Carron works of Scotland, which exist in the neighbourhood of Stirling. These works are on a scale which far exceeds any thing of the kind even in England. Their ore is the clay iron stone; their fuel, coak. The quality of their castings is such as to justify the high reputation which these works have acquired. The whole establishment belongs to a company, and is said to yield a very great profit; the amount of which we have not been able to ascertain.

Besides these works, there are other iron works of considerable importance in Scotland, in the neighbourhood of Glasgow.

For lead, Scotland has long been celebrated. The mines of Leadhill, Wanlockhead, and Strontian, are the only ones now worked. The mine of Leadhill is situated near Sanquhar, in Lanerkshire; it is remarkable for its interesting geological characters. It is worked with great activity and success. There is no silver, at least none worth extracting. A circumstance which we observed here, and nowhere else, but which we deem very interesting, is the successful use of peat, in large proportions with coal, for the smelting of the ore. This fuel appears to answer very well, and is very economical.*

* The mines of Leadhill possess an institution well worthy of being introduced into other mining districts; we allude to a library for the use of miners. This institution, formed on the same plan as the Apprentice's Library in this and other cities, is calculated to spread instruction among the lowest classes of miners. It contains many excellent works on the art of mining, besides a large stock of works of standard merit on religious, moral, and miscellaneous subjects. This cheap method of conveying information is peculiarly desirable for this class of the community. The hard and laborious operations of the miner take up but a small proportion of the hours of the day; the remaining hours are too often given up to dissipation or idleness. The nature of the country where mines are situated, generally shuts them out from the usual intercourse with strangers. It is, therefore, to such a class of men that a library containing a good choice of books on religious and moral subjects, together with the best works on their art, must be real-

Wanlockhead is in Dumfriesshire, about a mile to the south-west of Leadhill. The works are not so considerable, but this mine is like that of Leadhill, remarkable for the extent of the vein, and the richness of the ore.

The works at Strontian, in Argyleshire, are not so productive. They have been abandoned and resumed several times. Within a short time past, they have been, we think, resumed by a party of Cumberland miners, who expect to be well rewarded for their trouble.

These are, we believe, the only mines worked at present in Scotland; but great hopes are entertained of a recent discovery of copper ore, in Ayrshire; and attempts to work it have already been commenced there.

England is much richer in mines than the sister kingdom; for almost every metal is worked there. It is true, the English have found neither gold nor silver ores; but they afford us a convincing proof, if any were required, that it is more profitable and more advantageous for a nation to procure these metals by exchange for other more necessary articles, such as iron, copper, coal, &c. than to work them herself.

The mines of England are so well known to every person in this country, who has felt the least interest for this subject, that it cannot be necessary for us to say much on this topic; and we feel the more diffident in speaking of them, as the shortness of our stay in England has not permitted us to visit one of the most important districts, that of Cornwall. We shall, therefore, dwell principally upon the mines of the north of England, which we have seen, and solicit the particular indulgence of the reader for the very few remarks we may venture to make upon those of the south-west.

The north of England contains, undoubtedly, one of the most valuable deposits of coal known to exist any where. The mines of Newcastle are proverbial. They are situated

ly valuable. We do not recollect having seen a similar institution in any other mining district, but we believe that it exists also in Cornwall; at any rate, the example is a good one, and will, we hope, meet with imitators.

in the valley of the Tyne, and extend on both sides of the river for many miles. They are worked to a variable depth; we believe it has never exceeded two hundred fathoms. The subterraneous excavations are very extensive. There are some very large chambers for the reception of machinery. In the mine of Killingworth, we saw no less than three very large steam-engines, placed several hundred feet under ground, and the effect of which may probably exceed that of any three machines used in other mines.

It was in the coal mines of Newcastle that the safety lamp was first introduced; it has put a stop to the numerous accidents which formerly occurred there. The honour of the discovery of a lamp, upon a similar principle as Sir Humphry Davy's, though not on so improved a system, has been claimed by one of the best mining engineers of Newcastle, Mr. Stevenson, who conducts, with great ability, the works of Killingworth. But we believe there is at present no doubt that Sir Humphry has the full merit of the priority of discovery, as well as of the superiority of his lamp. A very ingenious method of preventing the evil effects of part of the inflammable gases, and one which we have seen practised with success at Newcastle, is to use this gas in lighting the mines, in the same manner as artificial gas lights are now used in most of the large cities in Great Britain. The usual method of ventilating their mines, is by constructing a large furnace at the bottom of one of the pits; a large fire is kept up in the furnace, which draws out all the impure air from the mine, while fresh air rushes in by another pit to supply its place. The draught kept up in this manner answers all purposes, and the air in the mines is, for the most part, very pure and wholesome. One of the most interesting applications of the steam power which we saw there, was the steam wagon or locomotive engine. It is a curious thing to see ten or a dozen of wagons moving on a high road, without being drawn by horses or any other visible agent. The steam engine is placed in the first wagon and sets it in motion, all the others are fastened to it and drawn along by it. This invention does not, however, appear to have met with much

encouragement. We believe it has been abandoned in almost every place where it was tried.

The yearly produce of the mines of Newcastle is immense. It is estimated by Mr. Winch,* at upwards of three millions of tons. Coal is worth, at the mouth of the pit, from seventeen to twenty shillings sterling a ton.

We cannot conclude our remarks on the mines of Newcastle, without making particular mention of the name of Mr. Buddle, civil engineer and viewer of Wallsend colliery, Newcastle. To this gentleman, not only the collier, but the miner in general, owes many of the most valuable improvements which the art of mining has made in England. To him are we indebted for the method of working coal mines called the *pannel working*,—for the introduction of iron cylinders in the tubbing of pits,—for various improvements in the ventilation of mines, &c.;—also, for his very active and humane efforts to bring the safety lamp into general use, &c.

Next in importance to the coal mines of Newcastle, are those of Whitehaven, on the west coast. They are worked upon the same system, but extend to a greater depth. Accidents were more frequent in these mines than in those on the Tyne, owing to a greater abundance of foul air; but the safety lamp has answered here as well as in the other mines.

The third coal field in importance in England, is that of Newcastle-under-Line, which extends over a considerable portion of Staffordshire. To this coal field the manufacturers of Birmingham and Manchester owe their flourishing condition. The great canal of England passes through it, and facilitates the transportation of the coal.

A fourth coal field exists in Glamorganshire, near Swansea, where a great proportion of the copper ore of Cornwall is sent to be smelted.

Many of the finest iron works of Great Britain are in the neighbourhood of the coal mines; thus we have the iron works near Wolverhampton, those of Colebrookdale, in

* Geological Transactions, Vol. IV.

Shropshire, second only to the Carron works; those of Merthyr Tydvil, of Lemmington-on-the-Tyne, and many others of great importance. Iron is the metal which England yields most abundantly, and in which she principally excels; to the quantity and superior quality of her iron castings, are to be attributed many of the improvements which the arts (especially the mechanical) have made in that country.

One of the greatest causes of the success of the iron works in England, is the use of the coak instead of the charcoal; the ore in common use is the clay iron stone, found in the coal mines or in their vicinity; so that the ore and the fuel are found almost in immediate contact; the carriage to the furnace is therefore but a trifling expense here, while it is a very considerable one in many other places. The clay iron stone is a very valuable ore, on account of the excellent quality of the castings which it produces; it appears that the most difficult operation, and that which requires most care, is the coaking of the coal and the proper selection of it.

The blast furnaces which are used in England are very high, they vary from forty to sixty, and even seventy feet in height.

In the art of refining the pigs, to make pure iron, the English have not been so successful; this is probably owing to the nature of their ores, or that of the fuel used; the fact, however, is well ascertained, that while the English castings surpass all others, the best iron used in England, and the only one used in the making of good steel, is imported from Sweden and Russia. With lead ores the English are likewise well provided; the principal mines are those of Derbyshire, near the Peak, and in Kingsfield. They have been worked for many centuries, and are now in great measure exhausted; they are found in the limestone, and some of them present very interesting geological facts.

The mines of the north of England are in a more flourishing condition, and constitute undoubtedly one of the richest deposits of lead known; they are situated at the junction of the three counties of Cumberland, Northumberland, and Durham; there are three centres of mines, viz. Alstone, Al-

lonheads, and Weardale Chapel; a great part of this property formerly belonged to the celebrated and unfortunate Earl of Derwentwater, who suffered on the scaffold, for his attachment to the cause of the Stuarts. In punishing this nobleman for his share in the rebellion of '45, the government was actuated more by the desire of acquiring his large estate, than by a wish to put a stop to the increasing discontents. After having kept possession of these mines for some time, the government bestowed a part of them upon the Greenwich Hospital, and they form no small part of the revenues of that institution. The most interesting and most profitable mines are, however, those of Allonheads, belonging to colonel Beaumont, one of the wealthiest men in the kingdom; his mines alone are said to support a population of from seven to eight thousand inhabitants. These mines are of pure galena, containing silver enough to defray the expenses of separating it. The principle upon which the method of extracting the silver is founded, is the same as in Germany, but the furnace used, and the manner of conducting the operation, are very different; we do not know which is the more economical of the two; it would be an interesting metallurgical problem to solve. The mines of this part of England are celebrated for the richness and abundance of their ores, for the talent with which the works are conducted, for the perfection of their metallurgical operations, for the economy with which they are directed, and for the profit which they yield.

The mines of Allonheads, Alstone Moor, and Weardale, are like those of Derbyshire, remarkable for the beauty of the fluor spar which they yield; we believe the green variety from Weardale, exceeds in beauty any thing of the kind which we have ever seen. At the mines of Coalcleugh, but a few miles from Alstone, there is a very interesting machine, called a pressing machine; it is the only one which exists in the mines of England. These machines are of Hungarian invention, and are very applicable in mines where great falls of water can be easily obtained, but where the volume of water is often small. The principal copper mines are in Cornwall, and in the isl-

and of Anglesea. Those of Cornwall are probably the most considerable in the world; they are situated near Redruth, extend to a very great depth, employ upwards of fifty steam-engines, and support a population which exceeds nine thousand inhabitants.

Those of Anglesea are in the mountain of Parys, require but little or no subterraneous digging, and are very easily worked; the ores are sent to Swansea to be smelted.*

Tin is found in England, in the dutchy of Cornwall, and in Devonshire, but principally in the former; these are the most valuable tin mines in Europe, and probably in the world; the best are those near Penzance and St. Just. The annual produce is about 18,000 blocks of 360 pounds weight each, which exceeds 300,000*l.* sterling in value; this product is about thirty times greater than that of the tin mines of Saxony.

England is not deficient in zinc. The best mines of calamine are found in Derbyshire, Cheshire, and Wales.

The salt mines of Norwich in Cheshire are remarkably rich, and their produce exceeds that of the mines of Wieliczka.

Mines of Ireland. Ireland is far behind her sister kingdoms in mineral wealth, or at least the wealth, if it exists, has not been taken advantage of there, as it has been in England and Scotland; the same causes which have retarded the prosperity of Ireland in every other respect, have done it also in mining. It would be labour lost to endeavour to find out a particular cause for every evil, when an universal one exists in the intolerant bigotry, and jealous oppression, which the English government has extended over this unfortunate island; let us hope that these causes are now about to disap-

* From Thompson's Annals of Philosophy, (New Series, No. 5, May, 1821,) it appears that the quantity of copper raised in England and Ireland, in one year, ending June, 1820, amounted to upwards of 8700 tons, which, at an average price of 120*l.* sterling per ton, makes the produce of England and Ireland, in copper alone, equal to 1,044,000*l.*, or upwards of $ 4,635,000.

The mines of Cornwall alone produced upwards of 6915 tons, the rest was supplied by Anglesea, Devon, Ecton, and Ireland.

pear. This year is the twentieth since the union of the three kingdoms, and according to the treaty of union, Ireland was to share, at the expiration of that term, all the privileges of the other two states. By the destruction of the barriers which checked her commerce, she will, we trust, be enabled to assume that rank in the British empire, to which she had long since been entitled, and of which nothing but the barbarous and unjust policy of England could have deprived her.

We have now given a short sketch of the state of mining in the principal parts of Europe; we have said little or nothing of Spain, Portugal, Italy, Denmark, and Russia, as they offer but little interest to the miner; Russia is celebrated for her iron, but this is produced by that part of the empire which is situated in Asia; the principal mines are in the Uralian mountains, at Blagodat and Keskamar, where the magnetic iron ore is worked with great success.

The silver mines of Zmeof and Kolivan, in the Altaian mountains, and the argentiferous lead mines of Nertchinsk in Daouria are celebrated, and are improving every day.

We have visited neither Sweden nor Norway, and we regret that our documents respecting the state of mining in those states are too loose and uncertain to allow of our saying any thing of them. They are now united under one government, and furnish the best iron and copper used in commerce; the produce in both these metals is considerable, and iron may be considered as a staple commodity of Sweden. The silver mines of Kongsberg and Sala have also acquired a great degree of celebrity: from the little we know of these two countries, we are inclined to think that the art of mining is no where better attended to.

We shall close these observations upon the actual state of mining in Europe, with a few remarks on the comparative state of the art in the three principal kingdoms, viz. England, France, and Germany.

From what we have said, it is, we think, apparent, that the mines of France are as yet in their infancy. They bid fair to increase rapidly in importance. The method which has

been followed, of uniting theory and practice, is very praiseworthy. We believe the great evil which the French have to dread, is that of falling too much into theoretic notions. They require that stimulus which proceeds in other countries from public spirit, or from a great desire of attaining wealth. If possessed of either of these, they would, we believe, give a greater scope to mining, render their country independent of all others, and benefit themselves. It is probable that the French will excel in the metallurgical arts, which are founded upon chemistry and much assisted by docimasy. In mechanics, they will, we believe, be rather behindhand, at least if we may judge from the slow progress which the steam power has made in France. As respects their academies of mines, we are fully of opinion that they will surpass all others. The French possess the art of teaching, to an unusual degree of excellence. The urbanity and attentions of their professors create among the students an enthusiasm in favour of the professor and of the science, which we have seen equalled nowhere. Besides the School of Mines in Paris, the government has established a practical school of mines, for the instruction of master-miners and foremen in mines. This school, situated in the centre of the coal field of St. Etienne, will contribute much to the advancement of the art. The liberality of the French government deserves not only to be admired, but also imitated, by other governments, especially by the monarchical, where so much money is at the disposal of the sovereign, who seldom employs it in the most judicious manner.

In Germany, the art of mining seems to have arrived at its climax, and to have been dormant of late; at least, the improvements in latter days have not been great. The Germans detest all ideas of change; but at the same time that this will guard them against dangerous and foolish innovations, it will also prevent them from making those improvements which the nature of things requires. They are too apt to follow an old routine. This is particularly the case in their metallurgical operations, which we would scarcely hesitate in saying, are far behind those of England. This

assertion must not, however, be extended to the iron works of Silesia, which are, we believe, equal to any in the world. In mechanics, the Germans are far superior to what they are generally thought to be. In no country, perhaps, has the use of the water power been employed with so much advantage and economy as it has been in Germany. It would be well if the steam-engines were more generally introduced, at least in some places, where fuel is cheap. The skilful and experienced gentleman to whom is at present intrusted the direction of the machinery in the mines of Saxony, is as well calculated for the high station which he occupies as any man we know of; and under his care, it is impossible that great improvements should not be made.* The Germans are a slow, persevering, and industrious nation. Hence, they are not so easily disgusted as their French neighbours. They never commence an undertaking hastily or rashly; but, having once undertaken it, they never reject or abandon it without having given it a fair trial.

One of the greatest encumbrances in the mines of Germany, particularly in those of Saxony, is, we believe, the great number of officers and under officers. The German mines have quite a host of directors and under-directors, agents, inspectors, supervisors, &c. besides master-miners and foremen in abundance; in a word, a system as expensive and as unprofitable as Napoleon's celebrated *Bureaucratie*.

One thing, in which the Germans excel all others, is the dressing of the ores; probably, also, in making subterranean draughts. The mining academies in Germany are those of Freyberg in Saxony, and of Schemnitz in Hungary. Of the former we have already spoken: the reputation of the latter has depreciated considerably, and it scarcely deserves to be named.

The emperor Alexander has lately established one in Poland, which requires time to mature it.

* Mr. Brendel, director-general of the mining machines in Saxony, is the first engineer who introduced steam-engines in the coal fields of that country. He is now engaged in constructing pressing engines for two of the mines in the Erzgebirge. He is a worthy successor of the great *Mende*.

In England, there is no school of miners. In the large cities, there are professors on the sciences connected with mining; but no practical information can be derived from them. Hence, the only means which the English have of improving themselves in mining, is to visit the mines, and to work in them. This method is certainly very good; but the English directors are frequently too deficient in theory, especially as the literature of the English miner is very limited, and not very good. The nature of their education and occupations prevents many of them from attending to the study of the German language, which every miner ought to acquire, as no language offers such a valuable stock of books on this subject.

But the great and ardent spirit of the British nation, their inventive power, the force of their genius, and their great turn for mechanics, will naturally cause them to excel in mining, as in every other art. Their mines are, it is true, too irregularly worked; but they are worked with profit; and that, after all, must be considered as the main object. Nowhere is the art more flourishing. This is owing to the active and enterprising character of the English miner, who has neither the levity of the French nor the heaviness of the German, but in whom we find a happy mixture of enterprise and perseverance, of enthusiasm in undertaking, and skill in accomplishing, his operations. It is also to the excellence of his laws, and to the freedom which he enjoys, that he is indebted for a portion of his success. Unfettered by an interference, often very injudicious, on the part of the government, he is left to regulate his works, and dispose of his own capital, according to his better judgment. We believe every proficient in the art of mining will be struck with surprise and pleasure, on first beholding the regularity and symmetry of the German mines; but upon closer investigation, he will often find that there is not, in many cases, that fitness, that economy of labour, which he might wish for. Too much is sacrificed to the desire of adhering strictly to a preconceived plan, and of dividing the mines into regular parallelograms, by streets and lanes at right angles, &c. In the English mines, on the contrary, we mark the disorder of genius, the

economy with which the works are directed, and the great principle which pervades the whole, that mines are to be worked only when and where they are profitable.

We now proceed to examine what advantages might accrue to the United States from the introduction of the art of mining, what obstacles would impede the progress of the miner, and how he is to overcome them.

We have stated the question as if no mines were worked in the United States at present. Lest this assertion should excite surprise, we hasten to explain. Almost all the metals have been found in the United States; but no works have been, we believe, undertaken with any degree of attention, except those of iron, lead, and coal. We do not believe copper has ever been smelted. Some attempts made in New Jersey, several years ago, from some cause or other proved unsuccessful. In Maryland, where a great quantity of copper ore exists, none has as yet been smelted.

Iron has, it is true, been much attended to; and the efforts of many of those who undertook this branch with skill and prudence, have met with the most complete success. The quality of part of our iron is said to excel that of any imported, even the Russian and Swedish. Several of the works are upon the largest scale, and would, we are told, do honour to England herself. Not having as yet visited any of them, we shall refrain from any remark upon the method used; but from common report, we are inclined to believe that it differs but little from that followed in Europe. However large some of our works may be, and however numerous they may appear, it is nevertheless true, that the quantity of pig and bar iron imported annually is very considerable.

The ores generally, or perhaps almost universally, used in the United States, are the bog iron ore, *(fer oxidé hydraté* of Haüy.) We know of some attempts which were made in Pennsylvania to smelt the clay iron stone, *(fer carbonaté des Houilleres,)* but we believe that they have hitherto been un-

successful. We have likewise heard of unsuccessful attempts to work the magnetic iron ore.

As to the specular and sparry iron ores, although they have been found in the United States, we have not heard of their being worked; nor are we certain that any very large quantities of them have been found.

When we recollect that the great superiority of the English castings is due to their improved method of working the clay iron stone, that the finest iron known is extracted from the magnetic ores of Sweden, that the German steel is produced by the sparry iron ore, and that the Elbese iron, whose reputation is so great, is obtained from the specular iron ore, we will remain convinced that it is impossible that the United States should not equal them in the works of pig and bar iron, and of steel, as soon as these ores shall have been worked properly. But these ores are not found in any considerable quantity at the surface: they require subterraneous works, and probably on this account have not been made the objects of regular establishments. All the iron furnaces consume ores which are found at the surface, with little or no digging; they are coarsely pounded and washed, and then sent to the furnace. Hence we are justified in saying, that although we have many very valuable and interesting iron works, we have as yet no regular iron mines.

There exist, in like manner, in the United States, no regular lead mines. The works on the Perkioming creek, which are perhaps the deepest and best concerted in the United States, have not yet yielded a single pound of metallic lead for commerce. The lead mines of Missouri are rich and abundant; but, from Mr. Schoolcraft's description, it is evident that nothing like regular mining has as yet been begun there; it is what the Germans very properly term a *Raubwerk*, a mere pilfering of the richest spots, without any attempt at regularity or system.

Our salt is all imported from foreign countries, or extracted from salt springs: we have as yet no mines of rock salt.

Coal appears to be the only article upon which something like mining has been undertaken. In most places, it is mere-

ly taken from the surface, or dug from the foot of a hill, in the manner of common quarries; but it appears, that in some instances, as in Virginia, there are regular pits and galleries, &c. but all on a small scale.

We must not omit to mention the gold mines of North Carolina, though the mining works are very inconsiderable.

Upon the whole, we think we may be warranted in saying, that there are as yet no mines in activity in the United States; and we may consider the undertaking of mines on a regular system as a new branch in this country.

The United States would undoubtedly derive from mining the same advantages which the prosecution of it affords to other nations. It would tend to make us independent of foreign countries for the most indispensable articles of commerce; it would secure to us an abundance of metallic substances, at a cheaper rate than that for which they could be imported; and, by increasing the quantity of metals, it is evident that we improve our arts and sciences, and make new advances in civilization. This is a corollary of one of the first propositions which we stated in the introduction. It is moreover corroborated by the instance taken from England. Where, might we ask, have the arts arrived at the highest degree of improvement? Where have they been most beneficially applied? What country equals England in the comforts as well as the necessities of life? And what, let us again ask, has elevated England to this high station? Is it not the prosperity of her mines? Is it not the abundance, excellent quality, and reduced price, of her cast iron? Is it not the invaluable assistance which she derives from her coal? All these advantages America may possess as soon as she pleases. No other country, on so slight an examination, has yielded such a rich harvest of ores to the mineralogist. If we confine our attention to our own state, we find, in almost every county of Pennsylvania, rich ores of iron. It is true, that as yet no bituminous coal has been found on this side of the Susquehanna, but we have no positive reason to think that it may not be found; besides, we have larger deposits of the anthracite than have ever been met with in any

other country; we see it already coming down the Delaware and the Schuylkill in abundance; we observe that it obtains a ready market; and, when experiments shall have been made with care, may we not hope to see it rendered useful in the metallurgical arts, perhaps even in the smelting of iron?

Another great advantage which the working of our ores will offer in many remote parts of the country, will be, the affording a market for the immense quantities of wood which our forests produce, and which are now allowed to grow and decay, without any interest being taken in improving or preserving them.

Nothing tends more to increase the population of a country than the working of mines. A mine may really be said to act as a magnet; it attracts and keeps together a population, which could not, without it, have found the means of supporting itself on the limited spot upon which it has settled.

The art of mining has likewise a good tendency to promote the morals and happiness of those concerned in it. It teaches men the necessity of mutual confidence, of activity and perseverance; it shows them that we are often nearest to the object of our wishes when we think ourselves to be most remote from it, and when nothing but a little perseverance is necessary to attain it. No part of the world exhibits a population more decent and orderly, or apparently happier, than the mining districts of Germany. The constant apprehension of the danger of mines, though this be more imaginary than real, habituates the soul to incessant reflection; and the sense of the impotence of human efforts entirely to avert the dangers to which the miner is exposed, naturally disposes him to turn to a superior Being, in whom alone he may place his trust. Never have we heard any thing more impressive than the prayers which the miners of Freyberg recite, all together, previous to their descending into the mines. They are such, that when once heard, the effect will long remain impressed upon the mind.

The introduction of the art of mining into the United States, will doubtless be attended with some inconvenience; and difficulties will at first offer, which may, however, be

counterbalanced by the natural advantages which our country enjoys, and which will disappear if the miner be not too easily discouraged.

In order to ascertain exactly the extent of these difficulties, let us inquire what are the points which ought principally to call the attention of the miner, and how each may be viewed in the United States.

Previous to the commencing of mining operations, it is the duty of the miner to ascertain exactly,

I. The nature and abundance of the ore.

II. The nature of the adjoining rock.

III. The price of labour, and the facilities to procure workmen.

IV. The nature and price of the fuel which the country affords, and the facility of obtaining it from a distance.

V. The price of timber, building materials, gunpowder, &c.

VI. The facilities for exportation, and the proximity of a market.

VII. The laws on mining.

A few remarks upon each of these points will explain the situation of the American miner, compared with the European.

I. As respects the *nature and abundance of the ore.* It is evident that this is the first object to be ascertained, and of the greatest importance, since upon it all hopes of success rest. It is likewise evident, that the rules and practice of other countries will apply equally well to our own, with this exception, that we will require, *cæteris paribus*, larger masses and purer ores;—because our country being as yet new in mining, it would be inexpedient for us to attend to our poor ore while we neglect the richer; it is only when these shall have been exhausted that the others will be worth working; especially, if we recollect that a poor ore not only produces less metal, but requires a much greater advance of money, and a more expensive treatment, inasmuch as the rock is more difficult to work in than the ore; and also, as a poor ore requires a great deal of washing and pounding, and that

this dressing demands the construction of machines, sometimes rather expensive; and, finally, a poor ore always consumes more fuel than a rich one. But, because we cannot work ores as poor as some of those worked in Europe, it does not follow that we must neglect all that are not so rich as their richest ores. Thus, though we could not work the copper pyrites of St. Bell, which yield but from 3 to 5 per cent. we may, perhaps, work ores that yield 10 per cent. or even less; and we must not reject them on the ground that some of the Cornish copper ores have yielded 80 per cent. It is probable that we could not work ores as poor as the silver and tin mines of Saxony afford, or as the gold mines of Hungary, because the expense of dressing the ore might perhaps exceed the value of the metal contained in it; neither could we work beds of so small a thickness as the cupriferous beds of the Mansfeld, for the quantity of ore yielded would not repay the expense of the excavation made to obtain it.*

II. *Nature of the rock.* This is also an object of great interest to the miner, on account of the many excavations which he has to make in it, and also on account of its proximity to the vein. Should it, for instance, be very tough and solid, his works will be costly, and of difficult execution. Should it, on the other hand, be loose and disaggregated, it will require more propping, and perhaps affect the security of the mine. The same observations which apply to the mines of Europe, may be considered as applicable to ours; with this exception, however, that many mines which are situated

* The price of labour is as great, and oftentimes greater, to work a vein of three inches, than one of three feet. This will be evident, if we reflect, that veins are for the most part broken up by cracks and fissures, that they present a number of *druses* and cavities, and are often more or less disintegrated, so as to render the work much easier than in the adjoining rock, which is often compact. In the abovementioned case, in working a vein of three inches, we would be obliged to open an excavation, the greater part of which would be in the adjoining solid rock, while the vein of three feet might be worked without breaking into the rock. In this case, therefore, the working of a vein of three feet would actually be attended with a smaller advance of capital, and the product would be twelve times greater.

in a very tough rock are very expensive to work by blasting, and that in this case the cheapness and abundance of wood in the United States, will allow us to apply the process of torrefaction in many instances where it is required, but where the scarcity of fuel will not allow the Europeans to use it. Another great economy may be found in the wood to prop the mines. We know, for instance, that all the wood used for that purpose in the coal mines of Newcastle, and probably in most of the mines of England, is imported into England from British America. It is evident that there must be a great saving in this respect in this country.*

In the very tough or very loose rocks, the miner will, perhaps, find it more economical for him to work in the United States than in Europe; but it is probable that in those of a moderate solidity, the balance of economy will run against us, on account of the price of labour, &c.

III. *The price of labour* is also an object of primary importance; and this, we think, will be the principal difficulty with which the American miner will have to contend.

1. The men will be difficult to procure.—2. They will be expensive.—3. They will be difficult to retain.

In procuring workmen, the difficulties are probably not near so great as they were a few years ago; but still, the great advantages which agriculture offers to the labouring class of the community, the facility with which they may become possessed of property, will, for a long time, prevent many from engaging as labourers in manufactures or mines.

Again, the art of the miner, (of the common labourer in the mine,) requires experience. There is a great choice in miners, and it seldom happens that a man in Europe is considered as a workman of the first class, until he has served a regular apprenticeship of several years in the mines. This is particularly true of smelters, whose trade is one of those in which experience and practice are most necessary. A careless or inexperienced hand will, perhaps, consume twice

* If we are not mistaken, the expense of wood from America, for the mines of Newcastle, amounts annually to upwards of 150,000*l.* sterling.

the quantity of fuel, or yield much less produce than a skilful one. In the common operation of the refining of lead, in order to separate the silver contained in it, we have frequently been able to observe the great difference which exists between the produce obtained in the same time and from the same quantity, by an experienced workman or by an apprentice.

In this country we will meet with but few men who may be said to have learnt this art by regular apprenticeship, and who can therefore be employed with advantage. Those few, conscious of their own importance, will be very expensive, and difficult to be kept in proper discipline.

It has often been suggested, to bring over workmen from the mining districts of Europe; but this is by no means unattended with difficulty. The workmen must either be from England or Germany:—we need not look to France for miners. The Germans are certainly the best workmen that could be brought over. Their general character, for prudence, moderation, and perseverance, would render them more manageable than any other class of Europeans. One of the great objections to the bringing over of foreigners is, that the first expense is considerable, and the facilities which they find in breaking their contracts, and leaving their employers, prevent these from being remunerated for their advance of funds. It is probably very true, that the mildness of our laws, the vast extent of our country, the facilities for travelling, and perhaps also too imprudent an interference on the part of some of the charitable societies, (instituted with the best of motives, by foreigners, for the protection of their countrymen arriving here, and for the purpose of assisting them with money and advice,) may in many cases prove the source of real injury to persons importing workmen from Europe, and open a door to this breach of faith. This evil is, we think, however, less to be apprehended on the part of the German, than of any other emigrant. The well-known moral rectitude of the German nation, equal to that of any other, the natural want of energy, and disinclination to roam about, are, we think, sufficient pledges in the hands of the employer, that few or none of the workmen whom he may

import from Germany will disappoint him. The difference in manners and language is another great argument in favour of the German emigrant, in preference to the English, who would find himself almost as much at home in this country as in England. A great means of insuring the faithful performance of their contracts, would be to bring over from Germany the families of the miners, and to allow them a small tract of land to settle upon. That miners could be obtained from Germany, cannot, we think, be doubted; for although not gifted with a great locomotive inclination, they would probably be allured by the hopes of settling in this country, of providing for the future maintenance of their families, and of receiving higher wages.

Although, therefore, we would not positively assert that it will be expedient to import workmen from abroad in all instances, still, we think that there may be cases in which such an introduction of foreigners would be attended with great advantages, and that in this case no country can afford us better miners, or men more worthy of our confidence, than Germany.

The second difficulty which would attend labour in the United States, would be its great expense. Certainly this is true as respects the difference of prices. On the continent of Europe, we think the average price of labour in the mining districts is under twenty cents per day. We have seen many places where it did not exceed ten cents. In England, the price is higher; and we think, in all the mines of the north of England, it averages, for the common miner, half a crown per day (fifty-five cents.) It is probable, that in many parts of the United States, at least of the Atlantic states, and at some distance from the cities, we might obtain workmen for nearly the same price. In the western states, the price would be much higher.* The price of labour is certainly an *item* of the first importance in our art, since there are many ope-

* Mr. Schoolcraft establishes the average price of labour at Potosi (Missouri) to be about two dollars per day.

rations which require manual labour, and in which it cannot be replaced by machinery. To economize it must be the principal object of the director's attention. He has two ways of doing this; first, by using horses, mules, and other animals, which will certainly be very economical in many places, where pasture is cheap, and provisions for these animals can be obtained at a low rate. The second method is the frequent and constant application of machinery wherever it is practicable. In this respect, we may consider ourselves as fortunate as the most favourably situated nations in Europe. The ingenuity and talent of our mechanics equal those of the same class in any other nation; their inventive powers have already secured to our country many lasting benefits. Whether we wish to introduce into our mines the steam or the water power, our country affords us great facilities.

The introduction of the steam-engine into mines, has produced such great and rapid improvements in the art, that we hope America will not be behindhand in employing it, especially as no country is so well provided with fuel as she is. Equally well-gifted is she in the means of setting up water powers. No country that we know of presents such numerous rivers, creeks, and streams of all sizes, as she does; thereby affording great falls of water, and allowing us to make a greater use of this power than any European nation. These will be our means for counteracting the higher wages which we will have to give our workmen.

Another consideration which affects labourers in mines, is the difficulty which we will probably experience in keeping them, who, besides the natural bent for change, may be allured away by hopes of bettering their situation, a wish of settling on property of their own, or by the offer of better wages from competitors. We hope that those concerned in mines will understand their interest better, than to establish a system of competition in outbidding their neighbours, in order to carry off their workmen. Such a system would be ruinous to themselves, and of but little profit to the workmen, upon whose moral character it must have a very bad influence, as it pre-

vents them from assuming regular habits, and, on the contrary, accustoms them to be in a state of perpetual restlessness, and also to endeavour to take advantage of any pretext to break their contracts with their employers, whenever they see the least chance of benefiting themselves by so doing.*

The best means of keeping workmen is, undoubtedly, to make oneself popular among them by being impartial in all instances, never departing from the strictest rules of justice, never taking advantage of them, particularly in their moments of difficulty, by lowering their wages unnecessarily. It is well to avoid as much as possible this fluctuation in the price of labour, which is always injurious to both parties.

A plan which we think would be attended with the greatest benefit, and which we have never seen used or recommended, would be, wherever the price of lands is not very high, to interest the workmen in remaining on the establishment, by promising to give them, after a certain time, a small tract of land, on which they might, in the meanwhile, be allowed to live free of expense; thus they would find themselves interested in improving the land before it belonged to them, in hopes that it might one day become their property; and after having improved it, they would be unwilling to leave the place, lest their labour on the spot should be lost. In this manner they would feel interested in remaining at the mine for several years, after which, the force of habit would endear them to the place.

This system would, we think, be peculiarly advantageous in the case of Germans, who would be delighted at the idea of securing to themselves and family a small property; with this class of men, promises of annuities to widows and orphan children of such as have lost their lives in the works, or of those who have well deserved of the owners, would, we think, have a favourable effect; at any rate it is certain that a

* It is with pleasure that we find that the cotton spinners of our country have very wisely refused to follow so ruinous a line of conduct as regards their workmen.

great deal may be effected in this manner, at little expense, by ministering to their comforts, assisting them in their necessities, showing particular attention to the sick and wounded; we have seen many instances where such a system had been brought into operation at a very trifling cost, and by making the directors of such establishments popular among the workmen, produced the happiest effects, and attached them to the spot; this would be particularly desirable in this country, in order to counteract their natural inclination for change.

IV. *The nature and price of the fuel* which the country affords, is the next subject for consideration; also, the facilities for obtaining it from a distance.

In this respect, it is confidently believed, that no country is so well situated as ours, and that it offers us advantages equal to those of any other, England herself not excepted. The different kinds of fuel used are wood and charcoal, coal and coak, peat and anthracite; as respects wood, we are better supplied than any nation in Europe, except Russia and Sweden; not only our wood is abundant, but it is excellent; and we have a greater variety than any other country, so that we may select whichever we prefer; the hickory is the most valuable production of our forest, and is unknown in Europe.

In the metallurgical arts, wood is generally used in the state of charcoal, and for some purposes charcoal is the only fuel that can be used; here, of course, our advantage over other nations will be great. In coal, and its resulting product coak, we are not as yet so well favoured as England, for we have not as yet been able to ascertain its presence on the eastern side of the Great Valley of the Susquehanna; all our mines to the westward will be abundantly supplied with it, and should it never be found on this side, no doubt great quantities of it can be sent by the canal between the Alleghany and Susquehanna, which, we believe, it is now admitted on all hands, will soon follow the execution of the Union Canal; even at present we obtain coal from England, at a price which may be considered as tolerably reasonable.

Peat is but a poor substitute for wood or coal; it is, however, used in metallurgy, especially where a great heat is not required, as in the separation of the mercury from the silver, subsequent to the amalgamation, at Freyberg in Saxony: we have already mentioned that it was used at Leadhills in Scotland, for the purpose of smelting the lead ore. It is probable that we shall but seldom find ourselves obliged to recur to it; at any rate, should it be wanted, it will be found very abundantly in the United States.

Anthracite is very abundant, and exists in large quantities in the United States; it has, we believe, nowhere been applied, as yet, to the working of ores, but may perhaps be used with advantage by making a few modifications in the form of the furnaces.

Hence, we see that fuel is abundant and cheap in this country, and it may easily be brought to the places where it is needed, on account of the great facilities afforded by internal navigation.

V. *The price of the materials used,* such as timber, tools, gunpowder, &c. is the fifth consideration which ought to precede the working of mines. In this respect, it is probable that the advantages in this country will nearly balance those of foreign countries; some articles will be higher here, while others will be cheaper; in timber we will find a great saving, which will probably make up for the additional expense in iron, steel, powder, &c.

VI. Another object of high importance is the facility of exportation, and proximity of a market; no country in the world has been so much favoured by nature as ours has been in this respect; it is sufficient to cast our eyes upon the map of the United States, to be convinced of our great superiority in this respect; if we confine our attention to Pennsylvania, the remark is peculiarly obvious; we may safely ask, what country in Europe offers three such streams as the Delaware, the Susquehanna, and the Alleghany, besides the numberless tributary streams, which would well pass for important rivers in many other countries?

The only thing that is required of us in this respect, is to improve the natural advantages which we already possess; to complete, as it were, the work which nature has so well commenced; for this, we have but to follow the example given by other nations; the experience of England shows what a great, what an astonishing increase in national prosperity attends the improvement in internal transportation: the state of New York has followed the example, and is already reaping the reward. Let all the other states reflect upon this, and then by a judicious application of funds, let them improve their roads and navigation; the beneficial effect of such measures will be very great, both for agriculture and the arts; and among these, none will derive more essential benefits than the art of mining.

VII. The last object which the miner has to examine, previous to commencing his operations, is the state of the laws on mining, existing in the country in which he thinks of undertaking works of this nature; we have seen, that in this respect the miner has, at present, in the United States, no laws to study but those which affect every kind of property in general.

The art of mining, like all others, ought to be undertaken only after mature reflection and deliberation; we never can hope for success in works hastily or rashly conceived: whenever, therefore, we may be desirous of introducing the art of mining into a new district, or a new country, we must take time to examine the subject coolly and deliberately. We have endeavoured to state the most important points to which the miner's attention ought to be directed; we have likewise tried to examine how far our country might be said to be fitted for the reception of this art; we believe that there are many places where mining would succeed in this country. Whether our reasons for believing this be correct

or not, is a question upon which every man acquainted with the resources of the country is competent to decide; and we shall think ourselves amply rewarded for our labour, if these remarks may induce others, better acquainted with the state of the country, to examine the subject; and whatever may be the result of their examination, we think it will not have been an unimportant question to this country, to ascertain whether or not the United States are sufficiently advanced in the arts, to insure the advantageous introduction of the ART OF MINING.

THE END.